No. 16-1830

United States Court of Appeals for the Federal Circuit

IN RE: AT&T INTELLECTUAL PROPERTY II, L.P.,

Appellant

Appeal from United States Patent and Trademark Office, Patent and Trial Appeal Board, Appeal 2015-007847, Reexamination Control 95/002,353

BRIEF OF APPELLANT AT&T INTELLECTUAL PROPERTY II, L.P.

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CERTIFICATE OF INTEREST

Counsel for Appellant certifies the following:

1. The full name of every party represented by me is:

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2. The name of the real party in interest represented by me is:

AT&T Intellectual Property II, L.P.

3. All parent corporations and any publicly held companies that own 10 percent or more of the stock of the party or amicus curiae represented by me are:

The following are the owners of AT&T Intellectual Property II, LP: (1) AT&T Intellectual Property I, L.P.; (2) AT&T Intellectual Property Marketing, LLC; (3) AT&T Intellectual Property, LLC; (4) AT&T Mobility II LLC; and (5) AT&T Properties, LLC. None of the aforementioned companies is a publicly traded company. All of the aforementioned companies are subsidiaries of AT&T Inc. AT&T Inc. is a publicly traded company, and there is no one person or group that owns 10% or more of the stock of AT&T Inc.

4. The names of all law firms and the partners or associates who appeared for AT&T Intellectual Property II, L.P. in proceedings before the United States Patent Trial and Appeal Board, or are expected to appear in this Court, and who are not already listed on the docket, are:

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DATE: July 13, 2016

/s/ Constantine L. Trela, Jr.
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STATEMENT OF RELATED CASES

No appeal in or from the same proceeding in the United States Patent and Trademark Office (PTO) was previously before this Court or any other appellate court. Counsel for Appellant AT&T Intellectual Property II, L.P. (AT&T) is not aware of any case in this or any other court that will directly affect or be directly affected by this Court's decision in this appeal.

INTRODUCTION

In 2008, the PTO awarded U.S. Patent No. 7,454,071 for an invention related to video compression technology, and that should be exactly where AT&T's patent rights still stand. Instead, AT&T has spent more than three years in reexamination proceedings that were defective from the outset: the PTO initiated an *inter partes* proceeding without the statutory authority to do so, and that proceeding then unfolded like a game of whack-a-mole, in which AT&T would knock down one meritless rejection only to see the PTO pop up with another. This led to a decision rejecting nine claims as anticipated that was as flawed substantively as it was amiss procedurally.

To begin with, the proceeding should never have started. Congress authorized the PTO to initiate an *inter partes* reexamination only when a request has been made, and the request shows that the requester is reasonably likely to prevail. 35 U.S.C. §§ 312 & 313 (2012).[1] Here, the PTO could not make the latter determination, which is a statutory prerequisite for *inter partes* reexamination. LG Electronics, Inc., filed a request for *inter partes* reexamination of the '071 patent based on a particular piece of prior art (Yang). Soon thereafter, and before the

[1] In September 2011, Congress enacted the America Invents Act (AIA), which amended and altered the procedures for *inter partes* reexamination, effective September 16, 2012. *See* Pub. L. No. 112–29, § 6, 125 Stat. 284, 299–305 (2011). Because LG filed on September 14, 2012, statutory and regulatory references are to the versions in effect at that time unless otherwise noted.

PTO acted on the request, LG notified the PTO that the request rested on a misreading of the Yang reference, was meritless, and should be terminated. According to LG, it had *no* reasonable likelihood of prevailing on the request, and so the request should be terminated or denied to avoid "unwarranted consumption" of PTO resources and "an unnecessary cloud on the '071 patent." (Appx0174.) That should have ended the matter under the governing statute, for without a requester who would be likely to prevail, the PTO was without authority to proceed. But the PTO ignored LG's submission, concluded that LG was somehow still a requester and likely to prevail, and initiated *inter partes* reexamination despite LG's clear disavowal and abdication. (Appx0197-200.) In doing so, the PTO exceeded its statutory authority for *inter partes* reexamination, and its after-the-fact justification and refusal even to consider LG's decision to terminate while it still mattered cannot erase that error.

That unusual beginning portended equally unusual proceedings on the merits. Despite LG's unambiguous attempt to terminate the process before it began, and its explanation that Yang did not call the validity of the '071 patent into question, *inter partes* reexamination went forward based on Yang. Both AT&T and LG promptly told the PTO, again, that the patentability question based on Yang that reexamination had been initiated to resolve should be resolved in favor of patentability. The examiner then agreed concerning Yang, but did not end the

reexamination. Instead, the examiner purported to find new grounds for rejection based on a different piece of prior art (Krause) that had been listed in an AT&T Information Disclosure Statement. AT&T explained why Krause did not anticipate the '071 patent's claims either, and, in an interview with the examiner, he seemingly agreed. But after AT&T made a clarifying amendment that it had been told would resolve any outstanding concerns, the examiner once more reformulated his anticipation rejection in the right of appeal notice, and the Board affirmed this latest iteration. Meanwhile, with the request abandoned, LG had long ago withdrawn from the case.

The result of this bizarre process—in which the PTO (but not the third-party requester) seemed bent on initiating and continuing *inter partes* reexamination proceedings and finding a basis for overturning its own initial patentability determination—was a Board decision that cannot withstand scrutiny. The stated basis for rejection was anticipation. In truth, however, it was a misguided attempt to re-label what would have been a poor obviousness case (had it been asserted) as an anticipation rejection—a line of reasoning this Court has regularly rejected. And the Board's decision reflects its suspect roots: the two points on which the Board based its affirmance of the rejection are demonstrably incorrect. The Court should reverse and restore AT&T's patent rights to what the actual parties to the

inter partes reexamination request—LG and AT&T—have said that they should be.

JURISDICTIONAL STATEMENT

On September 14, 2012, LG filed a request for *inter partes* reexamination pursuant to 35 U.S.C. § 311. Although LG soon thereafter sought to terminate the request before reexamination was granted (Appx0171-75), the PTO moved forward on its own. AT&T ultimately appealed the examiner's final decision to the Board pursuant to 35 U.S.C. §§ 134, 315. On December 31, 2015, the Board issued a decision affirming the rejection of certain claims. (Appx0001-09.) AT&T timely filed a notice of appeal on February 23, 2016. (Appx2500-01.) This Court has jurisdiction to review the Board's decision under 35 U.S.C. § 141.

STATEMENT OF ISSUES

1. Whether the PTO exceeded its authority and acted outside its statutory jurisdiction by initiating *inter partes* reexamination and finding that the third-party requester had a reasonable likelihood of success on the merits despite the third-party requester's prior abandonment of its request and unequivocal position that the request was unfounded and should be terminated.

2. Whether the Board's decision approving the examiner's anticipation rejection should be reversed because the two stated bases for the Board's decision

are not supported by substantial evidence and rest on an improper application of obviousness principles to a rejection based on anticipation.

3. Whether the Board's decision should be, at a minimum, vacated and remanded because the examiner articulated the rejection for the first time in the right of appeal notice and the PTO's repeated reformulations improperly hampered ordinary *inter partes* reexamination procedures and AT&T's ability to refute the rejection in the context of such proceedings.

STATEMENT OF THE CASE

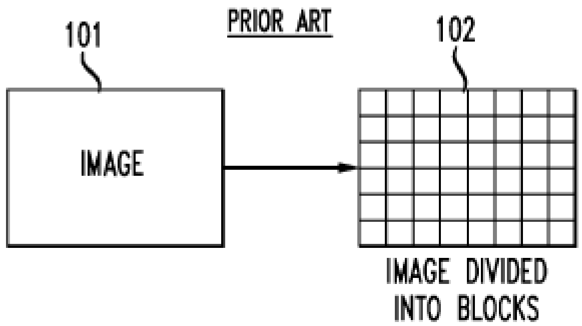
I. FACTUAL BACKGROUND AND AT&T'S INVENTION.

This case involves systems and methods for compressing and transmitting video and, in particular, two different ways to try to transmit higher quality images using smaller amounts of data.

A. Video And Image Coding.

Videos and images, especially high-definition digital videos, require large amounts of data. Videos are comprised of successive images, and "a typical video segment contains tens of images every second." (Appx0036(3:60-62).) Each image, in turn, can be subdivided into much smaller "blocks," with one image "contain[ing] hundreds, or even thousands, of blocks." (Appx0036(3:60-62).) For example:

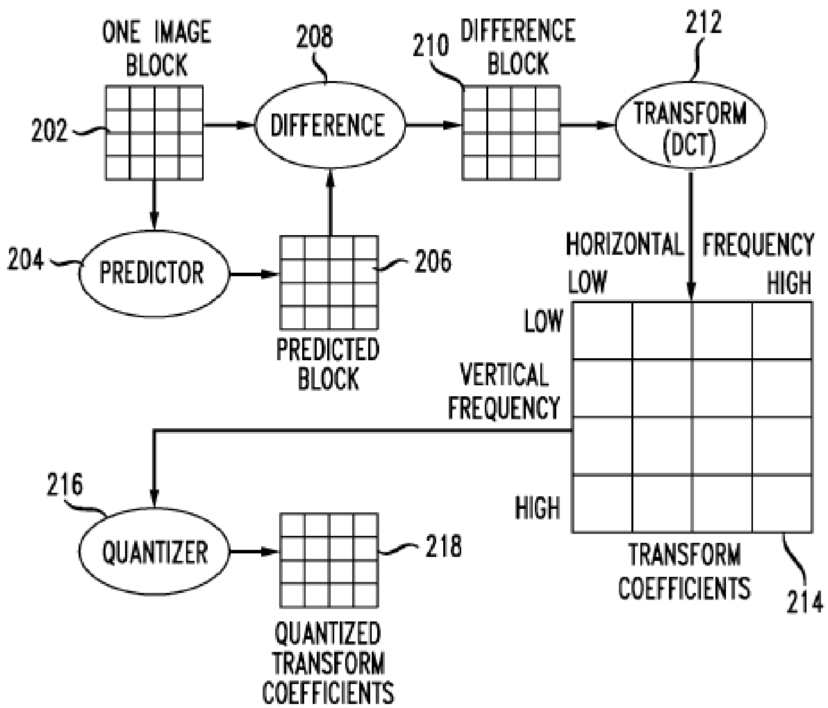
FIG. 1



(Appx0029.) These blocks are themselves made up of a discrete number of tiny dots or points, called pixels. (Appx0035(1:34-40); Appx0048(6:39-61).) In other words, an image can be broken down into blocks of pixels, all of which together make up the whole image.

Chopping up an image in such a way allows for more efficient digital transmission. A well-known first step is a process called "transform coding," which is "the heart of several industry standards for image and video compression." (Appx0035(1:15-16).) Each pixel has a particular color and intensity, and transform coding uses algorithms to transform an image's pixel data into a set of numerical representations, called transform coefficients. (Appx0048(6:39-61).) Such coding methods "exploit[] the fact that for typical images a large amount of signal energy is concentrated in a small number of coefficients." (Appx0035(1:23-25).) A particularly common coding method, known as discrete cosine transform (DCT), produces a matrix of transform coefficients arranged such that the highest energy or amplitude values are

concentrated in the top-left of the block, and those values progressively decrease as they move down and to the right. The '071 patent provides an example in which the values of low-frequency coefficients in block 214 would be larger than the values of high-frequency ones:

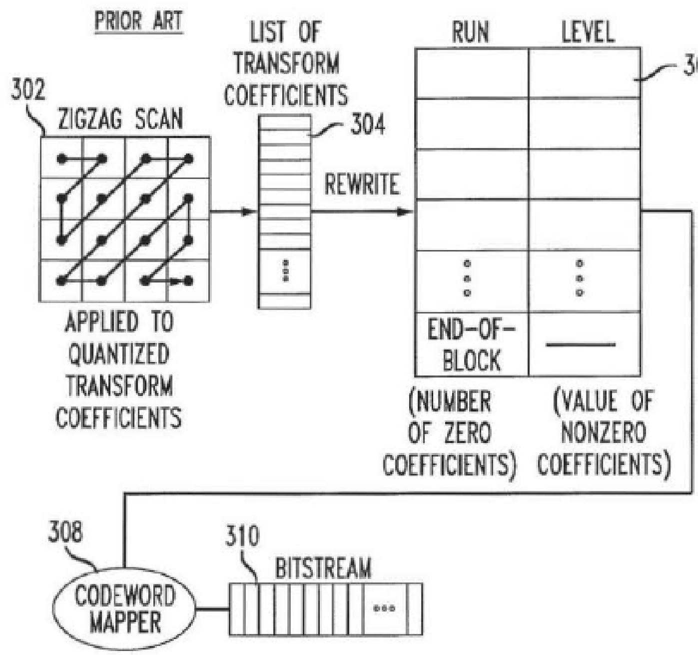


(Appx0029.)

This reorganization of the coefficients allows for further reduction in the amount of image data to be transmitted. In particular, the transform coefficients can then be "quantized" (216), which is essentially a way of reducing the size of the numbers to decrease the amount of data that is ultimately sent. Because the human eye is more critical of errors in the low-frequency range (the top-left), quantization tends to focus on the smaller-value coefficients in the bottom right,

where viewers are less likely to notice loss of data in the coefficients. (Appx0035(2:6-16); Appx0046(2:7-32).) Through quantization, "all, some, or none of the [transform] coefficients become zero," and the "coarser the quantization, … the more coefficients become 0 and the worse the reconstructed image looks." (Appx0035(2:10-11); Appx0036(3:53-57).) The upshot is that what started as a block of pixel data becomes a rearranged matrix of quantized transform coefficients—both zero and non-zero numbers—that can be encoded and digitally transmitted more efficiently.

The ultimate goal, of course, is to reconstruct the image after the data are transmitted, and that requires keeping track of the transform coefficients' locations. Prior art did so by scanning the block of transform coefficients in a particular order, starting in the top-left and zigzagging down the block:



(Appx0030; *see also* Appx0042.) Because the zigzag scan moves through the coefficients from largest to smallest, such a scanning pattern should yield a list of coefficients that includes long strings of zeros, especially towards the end. Prior art coding methods could then account for these strings of zeros by recording the number of zeros before the next non-zero coefficient—a figure called the "run" or "run-length"—rather than recording each individual zero coefficient itself. (Appx0035(1:57-67, 2:23-29); Appx0046(2:26-67).) The more zeros there are in a row, therefore, the greater the compression efficiency that could be achieved. (Appx0046(2:26-33).)

There were, however, deficiencies in such methods. For one thing, compression efficiency was tied to a particular scan order, like the zigzag. (Appx0035(1:11-13, 2:30-39); Appx0047(3:4-11).) For another, such techniques required "careful tuning of the coder" ahead of time, and "fail[ed] to take advantage of correlations between coefficients other than those implied by the fixed coefficient ordering." (Appx0035(2:30-39).) Both Krause and the '071 patent identified and sought to improve upon zigzag scanning and coding techniques, but they did so in very different ways.

B. U.S. Patent No. 5,295,203 To Krause.

Krause set out to try to "provide a method and apparatus for encoding video transform coefficient address information that overcomes the problems inherent in

the runlength coding method"—most notably, the fact that "the efficiency of the runlength coding method depends on the order in which the coefficients are scanned." (Appx0047(3:4-16).) The patent thus emphasizes that, "[i]n the vector coding scheme of the present invention, no particular scanning pattern is required to maintain a high compression efficiency." (Appx0049(7:25-27); *see also* Appx0049(8:59-63) ("the efficiency of the vector coding method does not depend on any particular scanning order").)

Having discarded the efficiencies gained through zigzag scanning and the accompanying long runs of zero coefficients, the fundamental idea behind Krause was to gain efficiency by encoding and transmitting *fewer* than all of the block's coefficients at one time. By dealing with groups or subsets of the coefficients in a block rather than all of them, thereby reducing the number of coefficients being handled at any point, Krause hoped to achieve efficiency with smaller-sized transmissions that did not depend on a definitive or predetermined scan order. In short, "it [wa]s desirable to reduce the size of the region that is vector coded." (Appx0049(7:65-69).)

The principal way Krause taught to do so—and what the patent repeatedly characterizes as its "present invention"—was to divide the block into so-called regions. Figures 4 through 7 illustrate transmission "in accordance with the

present invention." (Appx0048(6:15-24).) Figure 4 shows an 8 x 8 block subdivided into four 16-coefficient regions:

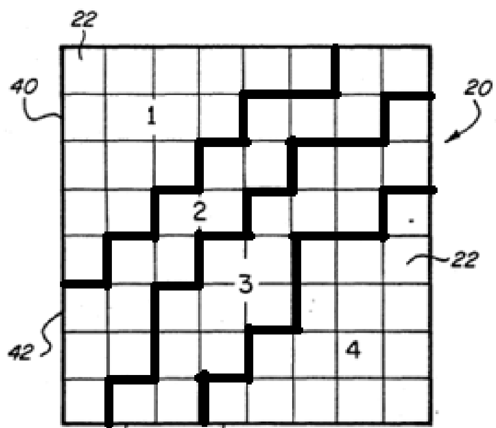
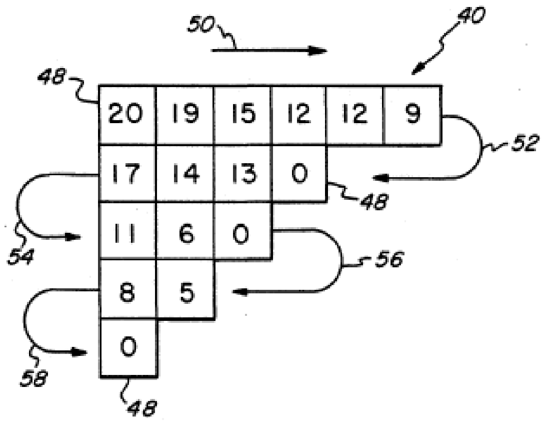


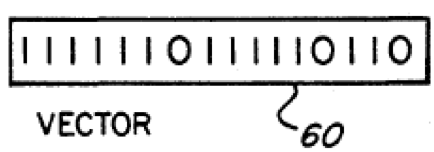
FIG. 4

(Appx0042 (enhanced for clarity); Appx0049(7:68-8:3).) This illustrated division "was chosen in order to maximize the number of coefficients that are likely to be greater than zero" in the regions as they progress from region 1 (top left) down to region 4 (bottom right). (Appx0049(8:17-25).)

Figure 5 then shows "how a vector can be formed by scanning the coefficients in first region 40" of Figure 4. (Appx0049(8:29-31).)



(Appx0043.) The numbers "represent the actual amplitudes of the sixteen coefficients residing in the region," and the coefficients are scanned in a snaking pattern from the top row to the bottom row. (Appx0049(8:31-41).) From this, "[a] vector is formed … to indicate whether each of the sixteen coefficients has an amplitude of zero or greater than zero" (Appx0049(8:41-43)):



(Appx0043.) In other words, the vector 60 indicates that there are zeros in the seventh, thirteenth, and sixteenth positions of region 1 based on "the order in which the coefficients of the region have been scanned." (Appx0049(8:50-53).)

Figures 6 and 7 and the specification's associated descriptions explain further how the encoding and decoding work for "the present invention." (Appx0044-45; Appx0049-50(8:64-10:56).) Vectors and coefficients are encoded to form "vector code words" and "coefficient code words." (*Id.*) The vector code

words have a "maximum code word length [of] nineteen bits"—16 bits for each of the 16 coefficients represented in vector 60, plus regional "tag" bits to denote the vector's corresponding region and an "end-of-block (EOB) bit" to "indicate[] whether there are any remaining nonzero coefficients in the vectors which follow." (Appx0050(9:11-23, 9:54-56).) The end-of-block bits thus serve, as their name suggests, to mark when only zeros remain in the block and when "the encoding process can be terminated early." (Appx0050(9:19-43).) If subsequent regions are composed entirely of zeros, no vectors are transmitted for those regions and efficiency accordingly increases.

In sum, in Krause, "blocks of transform coefficients are divided into a plurality of regions, that are chosen to maximize the number of coefficients that are likely to be greater than zero for a first vector, with subsequent regions producing vectors that are successively less likely to contain nonzero coefficients." (Appx0051(11:20-26).) The scan order of any particular group or subset of coefficients does not matter, because efficiency is produced by reducing the number of regions for which vectors are transmitted.

C. AT&T's '071 Patent.

The '071 patent approached the same problem differently. Far from seeking to transmit smaller groups, subsets, and regions of coefficients, as Krause did, it embraced the use of a single vector to transmit the coefficient data for an entire

block all at once and the efficiencies that could be gained through such a one-shot approach.

Like Krause, the '071 patent spells out several aspects of the prior art on which it improves. To begin with, it promises to "eliminate[] two-dimensional coding of transform coefficients and the requisite zigzag scan order or alternate scan order." (Appx0035(1:11-13).) Much of the background discussion then focuses on deficiencies with such coding methods. Among other things, they "require[] careful tuning of the coder" ahead of time such that the following entities are "carefully designed and matched to each other: (1) the coefficient ordering; (2) the variable length code; and (3) the matching of (run, level) pairs and the end-of-block condition to codewords." (Appx0035(2:30-35).)

Unlike Krause, the '071 patent solves these problems by transmitting a "single entity" or vector for an entire block of image data. (Appx0037(6:15-21).) As the specification states, "the invention's principle is that all the zero and non-zero coefficient information is combined into a single entity for coding." (Appx0036(4:43-48).) (A vector is simply a particular example of a single entity. (*Id.*)) This technique achieves efficiencies in several ways. First, it does not require bits or information beyond the coefficients themselves—for example, there are no tags for regions and, with the whole block's data being sent at once, "[f]urther improved coding and decoding efficiency may be achieved by removing

the need for an end-of-block signal." (Appx0036(3:17-24).) In a similar vein, the '071 patent explains in detail how to use probabilistic coding methods to reduce the size of what is transmitted and thus to increase the transmission efficiency. Figures 7 (for encoding the vectors) and 8 (for encoding the non-zero coefficients) depict such methods:

FIG. 7

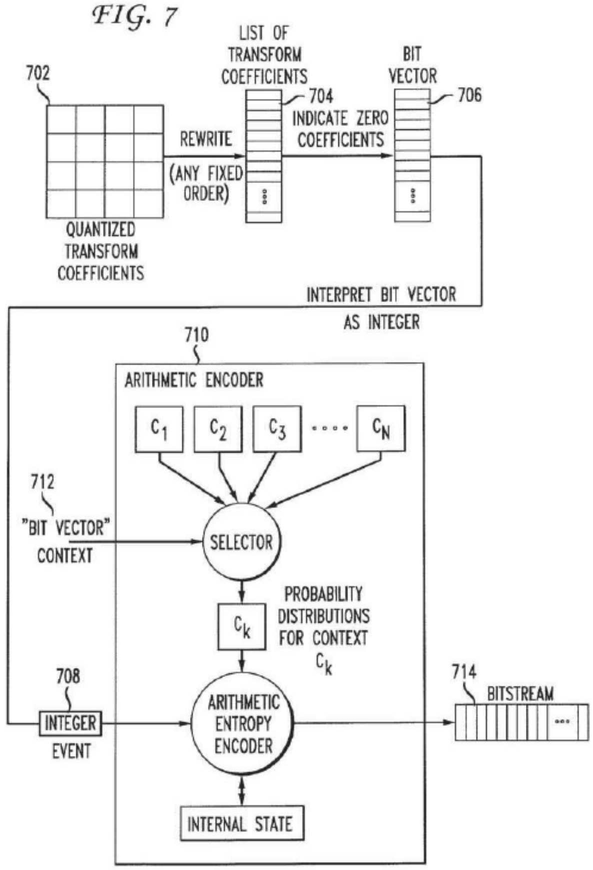
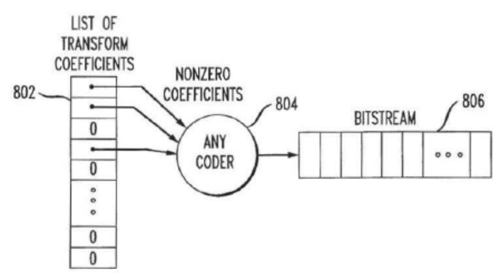


FIG. 8



(Appx0033-34; *see also* App0036-37(4:31-5:36).) These encoding techniques offer many advantages, including that they require "no human intervention … in the tuning process [and] automatically detect[] correlations among the various

coefficients through the adaptation of the bit vector probability distributions.” (Appx0037(5:55-66).)

The patent contains 35 claims, but these proceedings have focused on independent claim 1, which provides:

> 1. A method for identifying non-zero coefficients in a block of image data, the method comprising:
>
> mapping a block of transform coefficients into a one-dimensional list of transform coefficients in a fixed order;
>
> generating a single entity that identifies which transform coefficients in the one-dimensional list are non-zero; and
>
> coding the single entity.

Appx0037(6:15-21).)[2] The patent issued on November 18, 2008. (Appx0027.)

II. PROCEDURAL HISTORY

A. LG Requests *Inter Partes* Reexamination And Then Tries To Terminate The Request To No Avail.

The AIA’s *inter partes* review procedures went into effect on Sunday, September 16, 2012. The previous Friday, September 14, LG filed a request for reexamination of the ‘071 patent under the soon-to-be-extinct regime for *inter partes* reexamination pursuant to 35 U.S.C. § 311 and 37 C.F.R. § 1.913. LG’s request alleged that several claims were anticipated by and obvious in light of Wenye Yang’s and Jerry D. Gibson’s article, “Coefficient Rate and Significance

[2] During reexamination, AT&T amended the claim to state that the recited “block” is a “square block” of coefficients. The claim’s two references to a “block” thus now say “square block.” (Appx0003-6; *infra* at 23.)

Maps in Transform Coding," which appeared in the Conference Record of the Thirty-First Asilomar Conference on Signals, Systems & Computers, Vol. 2, pp. 1373-1377, November 2-5, 1997 (Yang). (Appx0060-61.) With respect to claim 1, for example, LG's request argued that Yang disclosed "[a] method for identifying non-zero coefficients in a block of image data [and] mapping a block of transform coefficients into a one-dimensional list of transform coefficient in a fixed order" through the concept of a "significance map." (Appx0082-83.) This significance map, according to LG, "inherently described" "each and every element … set forth in [claim 1]," and thus Yang anticipated various claims in the '071 patent. (Appx0067.)

LG quickly had second thoughts. In November 2012, before the PTO had even decided whether to *initiate* reexamination proceedings, LG filed a petition asking the PTO to terminate or deny the reexamination request altogether. (Appx0172-75; Appx2506-12.) LG recognized that the PTO's procedural rules barred the filing of any paper prior to the initial Office Action on a request for *inter partes* reexamination, 37 C.F.R. § 1.939, and specifically asked the PTO to waive that provision in light of the extraordinary circumstance presented by LG's decision to terminate its reexamination request altogether. (Appx0172-75.)[3] In its

[3] LG invoked 37 C.F.R. § 1.183, which provides that the Director may suspend or waive any of the PTO's procedural rules in "an extraordinary situation, when justice requires." Its petition to waive the operation of section 1.939 was

petition to terminate, LG told the PTO that it had "bec[o]me aware of information" showing that the significance map argument on which the request for reexamination was premised was meritless. (Appx0173-74; *see also* Appx2506-12.) In LG's words, therefore, it did "not believe there [wa]s a reasonable likelihood of prevailing with respect to any of the claims challenged in the Request," and terminating proceedings before they started would "avoid an unwarranted consumption" of PTO resources and "avoid an unnecessary cloud on the '071 patent." (Appx0174; *see also* Appx2506-12.)

There is no indication that the PTO or the examiner took this filing into consideration and every reason to think they did not. On December 3, 2012, about two weeks after LG's filing, the PTO granted the earlier-filed request for *inter partes* reexamination based on Yang. (Appx0196.) In direct contradiction to what LG had written in November, the examiner found that, "[b]ased on the … teachings in Yang, a reasonable likelihood of prevailing on the merits has been established by the request." (Appx0200; *see also* Appx0186-93.) The grant was thus expressly limited to the Yang reference that LG had raised, just as the relevant regulation provides it should have been. *See* 37 C.F.R. § 1.931(a) (*inter partes* reexamination can be ordered "for resolution of the question of whether the

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accompanied by the $1,930 petition fee, as required by section 1.183. (Appx0176-77.)

requester will prevail," when "it is found that there is a reasonable likelihood that the requester will").

AT&T and LG both responded. On January 24, 2013, AT&T filed a response requesting reconsideration and withdrawal of the rejections. (Appx0209.) AT&T first pointed out that LG had asked the PTO to terminate or deny the request and that the PTO had not acted on that filing, before explaining in detail why the rejections were wrong on merits. (Appx0211-40.) LG filed a comment on AT&T's response, "agree[ing]" with AT&T that the rejection of claim 1 was "based on a factual interpretation of Yang that is not consistent with Yang's disclosure." (Appx1429-33.) LG once more requested that the PTO "withdraw the rejections of record" and issue "an *Inter Partes* Reexamination Certificate … confirming the patentability of the patented claims." (Appx1433.)

Both of these filings discussed LG's still-pending petition from November 2012 asking the PTO to terminate or deny its reexamination request. On February 7, 2013, the PTO finally addressed LG's November termination petition. (Appx1437-43.) The PTO dismissed the November petition without considering its substance, finding that the agency's need to meet the three-month deadline to determine whether or not to institute reexamination proceedings was too important to allow LG to submit any materials in addition to the original *inter partes* request

before that deadline—even, evidently, materials asking that the request be terminated. (*Id*.)

B. The Examiner Purports To Find, And Then Scrambles To Justify, Different Rejections Based On A Different Piece Of Prior Art.

The examiner responded to AT&T's and LG's submissions on March 28, 2013. (Appx1444-56.) Now firmly aware that no one thought that the basis on which reexamination had been ordered was correct, the examiner agreed that AT&T's arguments were "sufficient to overcome the previous rejections" based on Yang. (Appx1447.)

That recognition, however, did not end the *inter partes* reexamination. Along with its initial response to the *inter partes* order, in January 2013, AT&T submitted an Information Disclosure Statement pursuant to 37 C.F.R. §§ 1.555, 1.933, and 1.98, listing a number of documents and publications. (Appx0248-55.) One of those documents was the '203 patent to Krause. (*Id.*) Having accepted that there was no basis for a rejection (or proceedings) based on Yang, the examiner's response to AT&T and LG nevertheless claimed that "new grounds of rejection appear[ed] … based on Krause." (Appx1447.) The examiner thus abandoned the initial rejections based on Yang and articulated new ones based on Krause, a reference the requester LG had never mentioned. (Appx1448-53.)

These new rejections were based *entirely* on Krause's illustrated disclosure of how to encode and send a vector from one *region* of a subdivided block.

(Appx1449-50.) The rejection of claim 1, for example, was for anticipation under 35 U.S.C. § 102(b). Limitation by limitation, the examiner found:

Limitation in claim 1 of the '071 patent	Allegedly anticipatory disclosure in Krause
mapping a block of transform coefficients into a one-dimensional list of transform coefficients in a fixed order	Figure 5's depiction of scanning the 16 coefficients in *a region* of the block can be extrapolated to cover an entire block
generating a single entity that identifies which transform coefficients in the one-dimensional list are non-zero	The 16-bit vector 60 in Figure 5 for *a region* can be extrapolated to cover an entire block
coding the single entity	A sentence from column 9 stating: "A read-only memory (ROM) 78 is used to map the sixteen bit coefficient word, the two bit region tag, and the EOB bit from bit processor 76 into a unique variable length code word."

(Appx1449-50.) According to the examiner, the fact that Krause's disclosure pertained to just one region of the block did not matter because the '071 patent stated in the background section that blocks may be "any shape at all." (Appx1449 (citing Appx0035(1:40-41)).)[4]

AT&T and the examiner then engaged in considerable back-and-forth about this particular rejection. At first, AT&T got nowhere. In May 2013, AT&T explained at length that the '071 patent is about encoding an *entire* block, and that

[4] Certain claims were rejected under 35 U.S.C. § 103(a) as being unpatentable over Krause in view of Meeker, but that did not change the nature of the rejections. Meeker was simply added "[t]o the extent that Krause does not teach a software implementation." (Appx1452.)

such a method is fundamentally different from Krause's disclosure about coding a *region* of the block. (Appx1476-88.) AT&T thus "again respectfully requested" "withdrawal of the rejection with a confirmation of the patentability." (Appx1485.) But the examiner remained unpersuaded—reiterating his belief that Krause's "region" corresponded to the "block" recited in the '071 patent claims—and issued a non-final action closing prosecution. (Appx1680-95.)

The next round started on August 30, 2013. AT&T's response argued that Krause's region was not a block of transform coefficients and that it was improper to equate the two based on a generalized statement in the '071 patent's background discussion that blocks could be any shape, because block shape does not speak to whether the invention applies to a whole block versus a partial or subdivided one. (Appx1717-48.) The same day, LG formally withdrew from the proceedings. (Appx1985.) With LG out, AT&T also filed a petition asking the PTO to suspend the usual prohibition in 37 C.F.R. § 1.955 on interviews during *inter partes* reexamination proceedings. (Appx1988-91.) The PTO granted that petition, allowing one interview subject to the examiner's approval. (Appx2002-07.)

The interview took place in January 2014 and focused exclusively on the only issue the examiner had to that point articulated—*i.e.*, whether Krause's single-region disclosure of Figure 5 anticipates the '071 patent's method for encoding an entire block of coefficients. (Appx2034-38.) AT&T explained why it

did not, including why "Krause requires that its irregularly shaped sub-region 40 be a portion of the block 20 of transform coefficients 22, and not a block of transform coefficients itself." (Appx2036.) The participants then seemed to settle on a resolution when the supervisory examiner "agreed that an amendment to independent claim 1 to explicitly state that the block of transform coefficients is a 'square' block would distinguish independent claim 1 over Krause," and the primary examiner "confirmed that such an amendment would be sufficient to overcome the anticipation rejection of independent claim 1" and the other rejections. (Appx2037.) The primary examiner also unsurprisingly "indicated that a rejection based on an obviousness rationale did not appear to be warranted." (*Id.*) And everyone agreed that the "most prudent manner for entering the proposed amendment" would be for the examiner to "promptly" "issue a further [action closing prosecution] in which he would acknowledge that entry of the proposed amendment would be appropriate and entered." (Appx2038.)

The action closing prosecution came promptly, but it contained no mention of an amendment. Instead, it floated an entirely new idea. (Appx2014-29.) As for the interview, the examiner did acknowledge that the discussion had focused on "Krause's sub-regions," but stated that no agreement was reached as to (1) whether the claims in the '071 patent are to "square" blocks or (2) whether it was appropriate to rely on the sentence of the '071 patent's background section

discussing irregularly shaped blocks. (Appx2033.) The actual rejections repeated familiar points about Krause's regions. (Appx2017-20; Appx2023-27.) Although not in the context of the rejections themselves (Appx2023-27), the examiner also tacked on a "Note Regarding Krause" at the end of the filing (Appx2020-21). This "Note" incorrectly suggested for the first time that, while Krause's preferred embodiment was to divide a block into regions, Krause *also* teaches how to perform the encoding method on an entire 8 x 8 block all at once. (Appx2020-21.)

AT&T filed another response in March 2014. (Appx2047-78.) AT&T began by offering the promised amendments to make clear that the '071 patent's claims cover an entire square block (Appx2049-50) and laying out why the rejections based on Krause were particularly improper in light of these amendments (Appx2056-73). At the end of the response, AT&T also stated that the "Note Regarding Krause" "appears to be separate from any grounds of rejection" but addressed it briefly "for completeness." (Appx2073-75.) AT&T explained that: (1) the Note misconstrued Krause, (2) Krause is not enabling for a single vector specifying *all* coefficients in a block, and (3) Krause's disclosure is directly contrary to such a coding and transmission method. (*Id.*)

On July 30, 2014, the examiner issued a right of appeal notice rejecting the same claims based on Krause. (Appx2082-102.) The examiner recognized that the bulk of AT&T's response and what had been the clear focus of proceedings

previously was "now moot" in light of the claim amendments. (Appx2090.) But the examiner pressed forward with the rejection, changing what had been a detached and tagalong "Note Regarding Krause" into the crux of a new basis for rejection. (Appx2088-99.) As for the first two limitations in claim 1 of the '071 patent, the allegedly anticipatory disclosures in Krause remained the same: the examiner stated that Figure 5's depiction of the snaking scan and vector for one region can be extrapolated to cover an entire block and that it thus disclosed "mapping a block of transform coefficients into a one-dimensional list of transform coefficients in a fixed order" and "generating a single entity that identifies which transform coefficients in the one-dimensional list are non-zero." (Appx2093-94; *compare* Appx1450-51.) With respect to the "coding the single entity" limitation, however, the examiner stated that the patent "discloses that the entire 8x8 square block can be processed in the same manner as an irregularly-shaped subregion of 16 coefficients." (Appx2095.) The examiner also brushed aside AT&T's additional arguments, reporting, for example, that Krause enabled an entire-block embodiment because it teaches that "the encoder must be capable of encoding 2^{64} possible combinations of coefficients." (Appx2091-92.)

C. The Board Affirms The Examiner's Latest Rejections.

AT&T appealed. (Appx2103-04.) In December 2015, the Board heard oral argument (Appx2470-99) and, that same month, affirmed the examiner's rejections

in a seven-and-a-half-page decision (Appx0001-9; Appx2459). The Board's reasoning was brief. It did not walk through the '071 patent's claim limitations or spell out a purported *prima facie* case of anticipation of those limitations. Instead, the Board made two main points.

First, the Board agreed with the examiner that Krause disclosed a method for "processing an entire block of transform coefficients" and encoding them into a single entity in column 7, line 58 through column 8, line 3. (Appx0004-5.) According to the Board, this passage represented "an express acknowledgement that the calculation of all possible combinations of coefficients which are non-zero within an entire block, while 'not easy,' was contemplated in the prior art." (Appx0006.) Citing to a discussion about how to transmit coefficients for a region of a block in column 8 of Krause, the Board also decided that Krause's teachings concerning the vector 60 for a particular region of a block "was appropriately appreciated by the Examiner to include the calculation of all possible combinations of coefficients which are non-zero within an entire block." (*Id.*) Although encoding an entire 8x8 block may have been "computationally complex," the Board "concur[red]" with the examiner that "nothing within Krause … suggests that Krause's technique must only be applied to sub-regions within an 8x8 block." (Appx0006-7.)

Second, the Board pointed to claims 1 and 2 of Krause as additional "evidence" for its view that nothing in Krause restricted the disclosure to sub-regions. In particular, the Board "note[d] claim 1 of Krause sets forth expressly the creation of a vector identifying locations of a group of coefficients from a block, [whereas] claim 2 expressly sets forth dividing the block up into a plurality of regions." (Appx0007.) The Board thus "conclude[d] that claim 1 of Krause does not require division of the block into a plurality of regions." (*Id.*) The rejections of the other claims followed from the rejection of claim 1. (Appx0007-8.)

SUMMARY OF ARGUMENT

I. The PTO's decision to initiate proceedings in the face of the requester's attempt to terminate its request was contrary to the statute and arbitrary and capricious. It was outside the statutory bounds because the PTO was authorized to initiate *inter partes* reexamination proceedings only when a request had been made and the agency determined that "there is a reasonable likelihood that *the requester* would prevail with respect to at least 1 of the claims challenged *in the request*." 35 U.S.C. § 312(a) (emphases added). When the requester seeks to terminate its request before proceedings begin and tells the PTO that there is no likelihood that it would prevail on its request, the statutory threshold requirements cannot be met, and the PTO was wrong to conclude otherwise.

More than that, the PTO's decision to first ignore and then dismiss LG's termination petition was arbitrary and capricious. Indeed, it was nonsensical. The PTO reasoned that LG could not seek a denial or termination of the request for *inter partes* reexamination because (1) LG was seeking an additional opportunity to argue the merits of the request and (2) allowing LG's filing would hamper the PTO's ability to meet the three-month deadline for deciding whether to grant reexamination requests. Both reasons are incomprehensible in the context of this case: asking to terminate a request as meritless is not seeking another chance to argue the merits, and, under any rational view of the world, recognizing LG's request to terminate proceedings would conserve resources and facilitate the agency's duty to meet the three-month deadline by dictating the answer. The PTO erred in initiating *inter partes* reexamination.

II. If the Court nonetheless concludes that the PTO properly instituted *inter partes* reexamination proceedings, the Board's decision rejecting claims from the '071 patent as anticipated should be reversed for at least two reasons. First, the rejection purports to be for anticipation, but it deviates well beyond that doctrine's exacting limits. Anticipation requires, among other things, that a single prior art reference disclose all elements of the claim, arranged as in the claim. Ambiguities and suggestions in the prior art are not such disclosures, and anticipation does not permit picking and choosing from different parts of a reference either. But that is

just what the Board did when it upheld the anticipation rejections based on separate and (at best) ambiguous pieces of Krause. The unusual nature of this *inter partes* reexamination surely played a role in the error: the PTO marched forward with proceedings that the requester tried to terminate before they started, expanded those proceedings in ways the requester likely could not have, and repeatedly refashioned the anticipation rejection as it groped for a valid theory that it never found. Where the PTO wound up at the conclusion of this process was a rejection that has all the markings of a shoddy obviousness theory erroneously lodged as an anticipation rejection.

Second, the Board's only two "findings" offered in support of the rejections are untenable. For the first, the Board took a passage in Krause that identified the problem Krause was trying to solve and Krause's solution for that problem and then read the passage to disclose an entirely different way of solving the same problem. But the mere identification of a difficulty in the art does not represent a disclosure of all possible ways to approach that difficulty. For the second "finding," the Board looked at Krause's claims 1 and 2 and observed that dependent claim 2 discloses dividing a block into regions while independent claim 1 does not. But that says nothing about what claim 1 *does* disclose, and the fact that claim 2 depends from (and thus narrows) claim 1 precludes a reading of claim

1 that describes an invention wholly distinct from that described in claim 2. The decision should be reversed.

III. If the Court does not reverse the Board's rejections, it should vacate and remand to the PTO. For starters, the PTO never formulated a *prima facie* anticipation rejection that could have shifted the burden to AT&T to show that the claims were not anticipated. The Board acted as if it had, but the third version of the PTO's rejection must—but does not—rest on a clear and unambiguous disclosure in Krause. If that shortcoming does not result in reversal, as it should, it should at least be grounds for vacating and remanding.

Adding to the need for remand should the Court not reverse, moreover, is the fact that the abnormal nature of the proceedings left AT&T without a fair opportunity to react to a rejection that was not adopted until the right of appeal notice, when proceedings were all but finished. That meant that: (1) AT&T's interview with the examiner was worthless, because it focused on a rejection theory that the examiner scrapped in the interim; (2) the PTO never adequately responded to AT&T's contention that Krause is not enabling for a single vector specifying all coefficients in a block; and (3) there was no expert testimony about what Krause does and does not disclose. The Court should reverse the unsupported anticipation rejections, but if it does not, it should vacate and remand

so that AT&T can respond to the PTO's belated rejection in the course of ordinary and orderly proceedings.

STANDARDS OF REVIEW

Statutory interpretation and questions of jurisdiction are reviewed *de novo.* *Belkin Int'l, Inc. v. Kappos,* 696 F.3d 1379, 1381 (Fed. Cir. 2012). "Anticipation … is a question of fact," and this Court "review[s] the Board's factual findings for substantial evidence and its legal conclusions without deference." *Kennametal, Inc. v. Ingersoll Cutting Tool Co.*, 780 F.3d 1376, 1381 (Fed. Cir. 2015). Substantial evidence is "such relevant evidence as a reasonable mind might accept as adequate to support a conclusion." *Consol. Edison Co. v. NLRB*, 305 U.S. 197, 229 (1938).

ARGUMENT

I. THE PATENT OFFICE'S INITIATION OF *INTER PARTES* REEXAMINATION WAS CONTRARY TO LAW AND AN ABUSE OF DISCRETION.

The PTO initiated *inter partes* reexamination of the '071 patent by granting a request from LG that LG had already asked the PTO to terminate. (Appx0186-93; Appx0172-75.) That was doubly problematic. First, because LG's "request" was effectively nonexistent, the PTO's decision to initiate *inter partes* reexamination was "in excess of [its] statutory … authority." 5 U.S.C. § 706(2)(C). Second, even if LG's request was technically still pending when the

PTO initiated *inter partes* reexamination, that was only because of the PTO's refusal even to acknowledge that LG sought, prior to the initiation decision, to terminate that request, a refusal that was "arbitrary, capricious, [and] an abuse of discretion," *id.* § 706(2)(A).[5]

A. The Patent Office Exceeded Its Statutory Authority By Granting A Defunct "Request."

The PTO's decision to initiate *inter partes* reexamination after LG sought to terminate its request was contrary to the governing statute. The subsequent decision to reject certain claims in the '071 patent was thus—in addition to being substantively without merit, *infra* § II—*ultra vires*.

1. The PTO is a limited agency: Congress has not granted it substantive rulemaking authority or generalized enforcement powers as it has other federal agencies. *See, e.g.*, *Merck & Co. v. Kessler*, 80 F.3d 1543, 1549-50 (Fed. Cir. 1996); 35 U.S.C. § 2. Rather, the PTO has authority to act only as specifically provided in its governing statute.

[5] Although the PTO's determination whether the information presented in a request shows "a reasonable likelihood that the requester would prevail" is "final and non-appealable" under 35 U.S.C. § 312(c), the question here does not concern the substance of the request, but whether the request—a statutory predicate for PTO jurisdiction—existed at all. As the Supreme Court recently observed, statutes like section 312(c) do not immunize from judicial scrutiny threshold questions of agency jurisdiction—that is, whether an "agency [acted] outside its statutory limits" or in an "arbitrary [and] capricious" manner. *Cuozzo Speed Techs., LLC v. Lee*, --- S. Ct. ---, 2016 WL 3369425, at *7-8 (June 20, 2016) (alteration in original).

Consistent with that, the basic contours of the statutory authorization for *inter partes* reexamination proceedings are expressly and repeatedly tied to the existence of a third-party requester. To start, section 311 permits "[a]ny third-party requester at any time [to] file a request for inter partes reexamination by the Office." 35 U.S.C. § 311(a). The request must be in writing, cite prior art, and "set forth the pertinency and manner of applying cited prior art to every claim for which reexamination is requested." *Id.* § 311(b)(2); *see also* 37 C.F.R. § 1.915 (providing additional direction). After that, the PTO must "determine whether the information presented in the request shows that there is a reasonable likelihood that *the requester* would prevail with respect to at least 1 of the claims challenged *in the request*." 35 U.S.C. § 312(a) (emphases added). If the PTO determines that it is reasonably likely that the *requester* would prevail, it issues "an order for inter partes reexamination of the patent for resolution of the question" presented *in the request*. *Id.* § 313. Throughout the process that follows, moreover, there is a statutorily-contemplated back-and-forth between the patent owner and the requester. *Id.* § 314(b)(2). *Ex parte* interviews and briefings are forbidden. *See id.* § 314(b)(1); 37 C.F.R. § 1.955.

This statutory scheme—in text and design—requires that a live request and requester exist for the PTO to have authority to initiate *inter partes* reexamination. Most significantly, sections 312 and 313 explicitly tie the PTO's authority to

initiate *inter partes* reexamination to the *requester's* chances of success: "the Director *shall* determine whether the information presented in the request shows that there is a reasonable likelihood that *the requester* would prevail." 35 U.S.C. § 312(a) (emphases added). Only if there is that reasonable likelihood can the reexamination be initiated. *Id.* § 313. "Unlike the word 'may,' which implies discretion, the word 'shall' usually connotes a requirement." *Kingdomware Techs., Inc. v. United States*, 136 S. Ct. 1969, 1977 (2016). So, if the requester has withdrawn its request and stipulated that its request has no chance of prevailing, then the determination that the Director "shall" make is preordained: there is, by definition, *no likelihood* that the *requester* would prevail. The *inter partes* reexamination statute does not authorize the PTO to make a determination about the patentability of claims in the abstract, or to determine whether someone other than the requester might prevail. The text demands an active requester, who is reasonably likely to prevail on the question presented in the request.

The textual command aligns with the statute's purpose and structure. Congress designed *inter partes* reexamination to provide "third parties greater opportunities to participate in the Patent Office's reexamination proceedings as well as in any appeal of a Patent Office decision." *Cuozzo Speed Techs., LLC v. Lee*, --- S. Ct. ---, 2016 WL 3369425, at *4 (June 20, 2016). In doing so, Congress swapped the *ex parte* interview process, common to reexamination under 35

U.S.C. §§ 301-307, for more adversarial proceedings between the patent owner and the requester. That swap would be meaningless if the supposed *inter partes* proceedings can be initiated after the third-party requester has abandoned its request and can then unfold with the patent owner having no third-party adversary. Nothing in the *inter partes* reexamination provisions authorizes the agency to initiate proceedings without a requester, just as courts do not press forward when a plaintiff wants out. On the contrary, the statute authorizes the initiation of *inter partes* reexamination proceedings only when there is a live request and a participating requester, *i.e.*, an actual party besides the patent owner. 35 U.S.C. § 312(a).

2. The PTO's decision to initiate *inter partes* reexamination proceedings after third-party requester LG sought to terminate its request and withdraw cannot be squared with the boundaries of the PTO's statutory authority.

To recap: on November 18, 2012, before the PTO had acted on LG's *inter partes* reexamination request, LG asked the PTO to terminate or deny the request. LG explained that it had become aware that the arguments in the request were wrong. (Appx0173-74.) LG did "not believe that there [was] a reasonable likelihood" it would prevail "with respect to any of the claims challenged in the Request" and sought to terminate the request "to avoid an unwarranted

consumption of the U.S. Patent and Trademark Office's resources and to further avoid an unnecessary cloud on the '071 patent." (Appx0174.)

LG's November filing negated the earlier-filed and unresolved request for reexamination and should have marked its demise. By ignoring LG's request to terminate and instead initiating *inter partes* reexamination (Appx0186), the PTO overstepped its statutory authorization. LG's petition to terminate made the statutory precondition for granting *inter partes* reexamination impossible to satisfy. Because the PTO's contrary action contravened the statute, it should be reversed. *See* 5 U.S.C. § 706(2)(C); *cf. McCormick Harvesting Mach. Co. v. Aultman*, 169 U.S. 606, 611-12 (1898) (reversing examiner's invalidation of patent outside statutory authority); *McAlear v. Merit Sys. Prot. Bd.*, 806 F.2d 1016, 1017 (Fed. Cir. 1986) (concluding that agency would exceed statutory authorization by ruling on a withdrawn request for attorney's fees).

B. The Patent Office's Decision Was Arbitrary, Capricious, And An Abuse Of Discretion.

Even if, through some hyper-technical procedural reasoning, the PTO could treat LG's request as still pending when the agency decided to initiate the reexamination, any such reasoning was arbitrary, capricious, and an abuse of discretion. 5 U.S.C. § 706(2)(A).

The Administrative Procedure Act prohibits agencies, including the PTO, from acting arbitrarily or capriciously. A decision is arbitrary and capricious if it:

"(1) is clearly unreasonable, arbitrary, or fanciful; (2) is based on an erroneous conclusion of law; (3) rests on clearly erroneous fact findings; or (4) involves a record that contains no evidence on which the Board could rationally base its decision." *Koninklijke Philips Elecs. N.V. v. Cardiac Sci. Operating Co.*, 590 F.3d 1326, 1334 (Fed. Cir. 2010). An agency also acts arbitrarily or capriciously when, for example, it fails to "examine the relevant data and articulate a satisfactory explanation for its action including a rational connection between the facts found and the choice made." *Daiichi Sankyo Co. v. Lee*, 791 F.3d 1373, 1379 (Fed. Cir. 2015).

The PTO's decision to ignore, and then belatedly dismiss, LG's termination request and to proceed to initiate *inter partes* reexamination was arbitrary and capricious. LG had made two separate filings seeking to terminate the request for reexamination because LG believed it was baseless, one of which was filed weeks before the agency acted on the reexamination request. (Appx00172; Appx2506-12; Appx1429-33.) In the second filing, made after the PTO had initiated *inter partes* reexamination despite LG's petition to terminate, LG once more disclaimed the merits of the reexamination request and said that the PTO "should withdraw the rejections of record and [issue] an *Inter Partes* Reexamination Certificate … confirming the patentability of the patented claims." (Appx1432-33.)

The PTO eventually got around to responding to LG's November 2012 filing on February 7, 2013, over two months after the previously abandoned request for *inter partes* reexamination had been granted. Even then, the PTO refused to consider the substance of the filing, and instead dismissed it. In particular, the agency refused to waive 37 C.F.R. § 1.939's "prohibit[ion] [on] filing … any unauthorized paper 'prior to the initial Office action on the merits' in an *inter partes* reexamination," because, it reasoned, the facts "d[id] not support a finding of an extraordinary situation." (Appx1441.) *See also* Manual of Patent Examining Procedure § 2667 (2015) (recognizing that the PTO may allow additional filings). According to the PTO, "[g]iving [LG] time to supplement the [request], together with giving the Office time to process the supplemental request, and then balance the added information against the original request, would severely impair the Office's ability to meet the statutory three-month deadline for issuing an order on the reexamination request." (Appx1441.) The PTO did not think that LG had "shown that its situation, where it feels that information in the request is inaccurate or incomplete, is extraordinarily different than that faced by other requesters." (*Id.*) For that reason, the PTO concluded, "justice has not been shown to require that [LG] be given an opportunity to argue the merits of the [request] twice (once in the original request and a second time in a Request for Denial)," and LG's petition to terminate or deny was dismissed. (Appx1442.)

Considered in light of the circumstances of this case, this decision is astounding, and arbitrary, capricious, and an abuse of discretion. To begin with, the PTO's characterization of LG's petition to terminate makes no sense. Far from seeking a second chance "to argue the merits of the [request]" (Appx1442), LG conceded that its request was merit*less*. (Appx0173-74.) LG thus tried to terminate the request or have the PTO take the ministerial step of denying it. This was not an effort to "supplement" the request or "put additional information before the Examiner before reexamination [wa]s ordered." (Appx1441.) Such characterizations might make some sense were the requester actually attempting to buttress a prior submission in order to *increase* the chances of obtaining *inter partes* reexamination. But they have no purchase here, and there is absolutely no "rational connection between the facts" and the PTO's reasoning. *Daiichi Sankyo Co.*, 791 F.3d at 1379.

In addition, the PTO's explanation and its ultimate decision are internally inconsistent. The PTO claimed that it could not consider LG's request to terminate the reexamination request, in part, because such a decision "would severely impair the Office's ability" to meet the since-expired three-month deadline for ruling on the reexamination request. (Appx1441.) That is upside down: under any circumstances, granting LG's unopposed request to terminate LG's own request for *inter partes* reexamination would necessarily take less time and expend fewer PTO

resources than continuing to consider a request that no one sought to pursue. And that is exactly what LG said: it asked that the request be terminated or denied "to avoid an unwarranted consumption of the U.S. Patent and Trademark Office's resources." (Appx0174.) The PTO's contrary reasoning was arbitrary and capricious. *See, e.g.*, *Gen. Chem. Corp. v. United States*, 817 F.2d 844, 846 (D.C. Cir. 1987) (agency action was arbitrary and capricious because it was "internally inconsistent and inadequately explained").

Indeed, the PTO has appreciated as much. The agency has, for example, granted requests to amend petitions for *inter partes* review to withdraw particular claims in order to conserve resources. *See, e.g.*, *Oracle Corp. v. Thought, Inc.*, No. IPR2014-00117, 2014 WL 1691918, at *2 (P.T.A.B. Apr. 25, 2014) ("The reduction of the challenged claims from claims 1-16 to claims 1-3, 6, and 7 supports efficient administration and timely completion of the proceeding."). Likewise, it has cited a cascading workload and need to avoid a backlog as justification for exercising its discretion to grant review on some but not all claims requested in a petition for *inter partes* review. *See Synopsys, Inc. v. Mentor Graphics Corp.*, 814 F.3d 1309, 1332 (Fed. Cir. 2016) (Newman, J., dissenting) (alteration in original) (quoting *Patent Reform: The Future of American Innovation: Hearing Before the Senate Comm. on the Judiciary*, 110th Cong. 7 (2007) (statement of Director Jon Dudas) ("[Q]uite frankly, without having the

resources available now, we are not certain that we could handle the administration of that many cases.”)); *cf.* Office Patent Trial Practice Guide, 77 Fed. Reg. 48756, 48757 (Aug. 14, 2012) (noting that the PTO must consider “the efficient administration of the Office” and “the ability of the Office to timely complete the proceedings” in developing regulations governing *inter partes* review). And the agency has recognized that efficient resolution benefits the parties as well. *See* Changes to Implement Inter Partes Review Proceedings, Post-Grant Review Proceedings, and Transitional Program for Covered Business Method Patents, 77 Fed. Reg. 48680, 48703 (Aug. 14, 2012) (“It is inefficient and unfair to patent owner[s] to require a full response to challenges on claims that do not meet the initial threshold.”).

The PTO’s insistence on enforcing generalized procedural rules without regard for the actual circumstances confronting it here, and then justifying that enforcement with reasoning that compels precisely the opposite conclusion, is arbitrary and capricious and an abuse of discretion. Although agencies have discretion in adopting and enforcing procedural rules, they cannot employ that discretion in an irrational way that results in action beyond their statutory jurisdiction. The PTO’s decision should be reversed.

II. IF THE COURT UPHOLDS THE PTO'S EXERCISE OF JURISDICTION OVER THIS *INTER PARTES* REEXAMINATION, THE *SUA SPONTE*, ELEVENTH-HOUR ANTICIPATION REJECTION SHOULD BE REVERSED.

The '071 patent claims a method for generating and coding a single entity or vector that identifies which coefficients in a square block of video data are non-zero. Only if Krause discloses that precise invention can there be anticipation. It does not, and the Board's decision to the contrary should be reversed.

A. The Patent Office Erroneously Adopted An Anticipation Rejection Based On A Misapplication Of Obviousness Principles.

"The tests for anticipation and obviousness are different." *Cohesive Techs., Inc. v. Waters Corp.*, 543 F.3d 1351, 1364 (Fed. Cir. 2008). Anticipation does not, for example, require "analysis of secondary considerations of nonobviousness." *Id.* In exchange for a more circumscribed inquiry, what anticipation does require is simple but strict: "[a] single prior art reference [must] disclos[e], either expressly or inherently, each limitation of a claim [to] invalidat[e] that claim." *Perricone v. Medicis Pharm. Corp.*, 432 F.3d 1368, 1375 (Fed. Cir. 2005); *see also* 35 U.S.C. § 102(b).

This Court has often recognized the important differences between anticipation and obviousness and the concomitant limitations on section 102's reach. First and foremost, for anticipation, the prior art reference "must not only disclose all elements of the claim within the four corners of the document, but must

also disclose those elements 'arranged as in the claim.'" *Net MoneyIN, Inc. v. VeriSign, Inc.*, 545 F.3d 1359, 1369 (Fed. Cir. 2008); *see also, e.g.*, *Abbott Labs. v. Sandoz, Inc.*, 544 F.3d 1341, 1345 (Fed. Cir. 2008) ("Anticipation is established by documentary evidence, and requires that every claim element and limitation is set forth in a single prior art reference, in the same form and order as in the claim."). That means, among other things, that "claims cannot be 'treated ... as mere catalogs of separate parts.'" *Therasense, Inc. v. Becton, Dickinson & Co.*, 593 F.3d 1325, 1332 (Fed. Cir. 2010) (omission in original).

This Court has made clear that these requirements have teeth. Alleged similarity of disclosures has no place in the anticipation inquiry: "[a] prior art disclosure that 'almost' meets that standard may render the claim invalid under § 103; it does not 'anticipate.'" *Connell v. Sears, Roebuck & Co.*, 722 F.2d 1542, 1548 (Fed. Cir. 1983). Put another way, "[d]ifferences between the prior art reference and a claimed invention, however slight, invoke the question of obviousness, not anticipation[, and] it is not enough that the prior art reference discloses … multiple, distinct teachings that the artisan might somehow combine to achieve the claimed invention." *Net MoneyIn*, 545 F.3d at 1371. Nor can there be "*any* need for picking, choosing, and combining various disclosures not directly related to each other by the teachings of the cited reference." *Application of Arkley*, 455 F.2d 586, 587 (C.C.P.A. 1972).

By the same token, suggestions and possibilities in the prior art do not amount to a disclosure of allegedly anticipated claims. *Cheese Sys., Inc. v. Tetra Pak Cheese & Powder Sys., Inc.*, 725 F.3d 1341 (Fed. Cir. 2013), is illustrative. The patents related to cheese-making vats and, in particular, the blade structure. Prior art generally taught blades that turned in the same direction, or “co-rotated,” whereas the patent at issue sought improvement by “counter-rotating” the shafts. *Id.* at 1343-44. The allegedly anticipatory patent focused on co-rotation but also stated, in the specification, that panels “can be arranged for counter rotation where specific production criteria demand it.” *Id.* at 1351. The Court rejected the argument that this possible design suggestion rendered the disclosure anticipatory: “[w]ithout a clear and unambiguous teaching, a jury could only speculate, hardly a compelling case for anticipation.” *Id.* at 1351-52. *Therasense* was similar. In that case, the Court held that a jury instruction was legally erroneous because it made “sufficient, for purposes of anticipation, a prior art disclosure of individual claim elements that ‘could have been arranged’ in a way that is not itself described or depicted in the anticipatory reference.” 593 F.3d at 1332; *see also Application of Wiggins*, 488 F.2d 538, 543 (C.C.P.A. 1973) (the naming of compounds in prior art, without more, “constituted nothing more than speculation about their potential or theoretical existence [and] cannot constitute a description of the compound”).

These principles were lost in the PTO's ever-evolving pursuit of an anticipation rejection of the '071 patent. The outsized and driving role that the PTO played in an *inter partes* process designed to settle disputes between private, adversarial parties led to a rejection that no longer resembled a valid anticipation theory and improperly crossed the line between anticipation and obviousness.

1. As explained above, Congress designed the *inter partes* reexamination process to be adversarial in nature and to allow the PTO to adjudicate claims raised by two private parties. *See Leo Pharm. Prods., Ltd. v. Rea*, 726 F.3d 1346, 1358 (Fed. Cir. 2013) ("during *inter partes* reexamination, the Board is reviewing evidence … submitted by two adversarial parties"). Such a process has benefits, because "a stake in the outcome ... assure[s] adversarial presentation and sharpen[s] the issues." *Nat'l Automatic Laundry & Cleaning Council v. Shultz*, 443 F.2d 689, 693 (D.C. Cir. 1971).

Both Congress and the PTO, moreover, set up *inter partes* reexamination proceedings to cabin what can be raised and presented in that adversarial setting. The initial decision whether even to initiate proceedings, for example, rests on the showing made in the request. The statute provides for reexamination where "the information *presented in the request* shows that there is a reasonable likelihood that the requester would prevail with respect to at least 1 of the claims challenged in the request." 35 U.S.C. § 312(a) (emphasis added). The PTO's implementing

regulation provides that the examiner is to "determine whether or not a substantial new question of patentability affecting any claim of the patent is raised *by the request and the prior art citation*." 37 C.F.R. § 1.923 (emphasis added). Where that showing is made, the Director is to issue "an order for inter partes reexamination of the patent for resolution of *the question*." 35 U.S.C. § 313 (emphasis added); *see also* 37 C.F.R. § 1.931(a) (order for "reexamination of the patent for resolution of *the question*.") (emphasis added).

After the decision is made to initiate the *inter partes* reexamination, moreover, the third-party requester is almost always required to limit its arguments to the question on which reexamination was ordered. The requester has a duty, for example, to "set forth the pertinency and manner of applying cited prior art to every claim for which reexamination [wa]s requested" in the application, 35 U.S.C. § 311(b)(2), and PTO regulations preclude it from raising new issues or prior art after reexamination begins except in narrow instances, 37 C.F.R. § 1.948. The request, and the arguments and art presented in it, both provide the basis on which the PTO is authorized to initiate the *inter partes* reexamination and define the scope of the proceeding once initiated.

Here, LG *tried* to play by these rules, but it made no difference. In particular, LG told the PTO—both before and after reexamination was ordered—that "the question" on which it had requested reexamination should be resolved in

AT&T's favor. (Appx0172-75; Appx1429-33.) In addition, LG never sought to raise any additional prior art, like Krause, and it is highly unlikely LG would have been able to do so after *inter partes* reexamination was instituted *based on Yang*. 35 U.S.C. § 311(b)(2); 37 C.F.R. § 1.948. Indeed, LG never even attempted to join or support the PTO's filings concerning Krause; LG simply withdrew. (Appx1985.)

The PTO, by contrast, became AT&T's adversary and, in the process, expanded the scope of this *inter partes* reexamination proceeding beyond what it was instituted to decide and beyond where LG could have taken it. The resulting anomalies undermined the normal decision-making process and gave rise to an unfounded anticipation rejection.

2. The agency's rejection—constructed at the last minute, after three iterations—does not adhere to the anticipation doctrine's core boundaries. Instead, it rests on a fusion of "multiple, distinct teachings" from Krause that a person might "somehow combine" by picking and choosing. *Net MoneyIn*, 545 F.3d at 1371; *see also Arkley*, 455 F.2d at 587. That is improper.

The examiner's rejection did not start this way. Even after Yang was abandoned, the examiner formulated and repeatedly defended an anticipation rejection based entirely on Krause's disclosure about encoding and transmitting the transform coefficients for a region of a block. (Appx1448-53; Appx2034-38.) In

other words, the rejection was founded on a single, cohesive disclosure in Krause, as anticipation must be. The problem was that Krause's teaching about transmitting coefficients for subdivided regions of a block has nothing to do with the '071 patent's claims, and AT&T's arguments and amendments eventually convinced the examiner of that. (Appx2090.)

So the examiner pivoted. To do so, however, required that he piece together different aspects of Krause and read too much into them. As ultimately articulated, the rejection was this: Krause's Figure 5 illustrating a scan and vector for *a region* can be extrapolated to cover an entire block and thus disclosed two of the '071 patent's limitations, and Krause's passing references to the entire 8x8 block and the prior art difficulty of encoding it disclosed the third. (Appx2093-95.) But that is not a viable anticipation rejection because it takes distinct and unrelated aspects of Krause—one illustrating in detail scanning and creating a vector for a region of a subdivided block, and another referring to the prior art problem presented by encoding the entire block—and combines them to assert anticipation. This mix-and-match approach does not and cannot show "that every claim element and limitation is set forth in [Krause] in the same form and order as in the claim." *Abbott*, 544 F.3d at 1345.

Not only that, but the aspect of Krause that the examiner seized on to try to extend Krause's limited disclosure to cover an entire block was speculative at best.

The most that can be said of Krause's stray references to the entire 8x8 block are that they allude to possibilities of what *might be* done, which is far from a disclosure of what is *actually* done and taught. That is, there is no "clear and unambiguous teaching" of whether or how someone could have extrapolated from Krause's teachings about transmitting subsets and regions of a block's coefficients to cover the entire block at once. *Cheese Sys.*, 725 F.3d at 1351-52. That is "hardly a compelling case for anticipation." *Id.*; *see also Therasense*, 593 F.3d at 1332; *Wiggins*, 488 F.2d at 543.

If this were not enough—and it should be—the Board's decision itself exposes the extent to which the PTO mistakenly tried to recast what would have been a bad obviousness theory—had it been presented—into an anticipation rejection. Perhaps most glaringly, in a key portion of the decision, the Board expressly relies on two *obviousness* cases to justify the misguided extension of Krause to the '071 patent for purposes of *anticipation*. (Appx0006 (citing *In re Heck*, 699 F.2d 1331 (Fed. Cir. 1983), and *In re Lemelson*, 397 F.2d 1006 (C.C.P.A. 1968)).) On top of that, the Board also "concur[red]" with the examiner's "find[ing] [that] there is nothing within Krause that suggests that Krause's technique must only be applied to sub-regions within an 8x8 block." (Appx0006-07.) But such a "finding" is backwards and has no place in an anticipation inquiry, which is about what the prior art *does* disclose and not what it

does *not* disclose or whether it happens to contain self-imposed limits. *Net MoneyIn*, 545 F.3d at 1369-71.

In short, the PTO's decision to take over and expand LG's abandoned *inter partes* reexamination request generated a fundamentally flawed anticipation rejection that should be reversed.

B. The Stated Bases For The Board's Decision Are Meritless And Unsupported.

The Board's error is equally apparent in the only two bases it offered for its decision. That decision represents the PTO's final word on the patentability of AT&T's claims and, as a result, forms the basis for this Court's review. *See, e.g.*, *In re Rambus*, 753 F.3d 1253, 1256-58 (Fed. Cir. 2014) (analyzing Board's stated basis for anticipation rejection and reversing when the Court "disagree[d]" with Board's view of prior art); *Power Integrations, Inc. v. Lee*, 797 F.3d 1318, 1325-26 (Fed. Cir. 2015) (vacating anticipation rejection when "the board's opinion provide[d] … an inadequate predicate upon which to evaluate its decision to reject claim … as anticipated," declining to "guess at the theory underlying the agency's action," and noting the "general proposition [that] review of a patentability determination is confined to "'the grounds upon which the Board actually relied'"); *In re Thrift*, 298 F.3d 1357, 1366 (Fed. Cir. 2002) (vacating and remanding Board rejection under *SEC v. Chenery Corp.*, 332 U.S. 194, 196 (1947)); *In re Sang-Su*

Lee, 277 F.3d 1338, 1342 (Fed. Cir. 2002) (describing the need for Board to provide "a full and reasoned explanation of its decision").

The Board here offered two conclusions over two pages to justify the rejections: (1) Krause's statement that it would be "not easy" to calculate all possible combinations of coefficients in a block meant that Krause's teaching as to regions could be extended to the whole block, and (2) the differences between Krause's claims 1 and 2 confirm that Krause does not require dividing a block into regions. Both conclusions are wrong.

1. The Board's first point does not concern a disclosure of anything. The full passage in Krause states:

> The number of possible coefficient combinations (i.e., locations in a block of transform coefficients having zero and nonzero entries) increases very rapidly as a function of the number of coefficients in the block or region. For example, the most popular transforms produce blocks of 8x8 coefficients. In this case, there are 2^{64} possible combinations of coefficients which are non-zero. Since it is not easy to implement a system capable of encoding or decoding this many code words, it is desirable to reduce the size of the region that is vector coded. For example, a block of 8x8 DCT or LOT coefficients can be subdivided into four regions as shown in FIG. 4. Each region 40, 42, 44, 46 contains 16 transform coefficients 22.

(Appx0049(7:58-8:3) (cited at Appx0006).) The Board construed this to mean that "the calculation of all possible combinations of coefficients which are non-zero within an entire block … was contemplated in the prior art" *and* that Krause's region-specific teaching was thus "appropriately appreciated" to include such a

calculation. (Appx0006.) Although it is not clear where such a "calculation" even fits into Krause's narrow, region-specific embodiment of Figure 5, the Board seems to be saying that this passage discloses how Figure 5's teaching could be performed on the whole block at once.

But the passage from Krause does no such thing. As context makes plain, the quotation is merely an identification of the problem Krause was attempting to solve, and a statement that the way Krause proposes to solve the problem is by subdividing blocks into regions and using multiple vectors. (Appx0049(7:58-8:3).) Such a statement is *at most* like saying that a person of skill in the art could "in reliance on [Krause] 'complete the work required for the ['071 patent's] invention'"—a conclusion that "relate[s] to obviousness, not anticipation." *Connell*, 722 F.2d at 1548. Indeed, the cited portion of Krause "not only does not place the public in possession of the invention, it effectively directs the public away from [a single-vector method]. Such a teaching is the antithesis of anticipation." *Application of Coker*, 463 F.2d 1344, 1348 (C.C.P.A. 1972) (emphasis omitted). Framing a problem and proposing one way to solve it does not simultaneously disclose a fundamentally different way to solve the same problem. The Board's finding to the contrary was error.

2. The Board's second contention is even more puzzling. As "further evidence" of the Board's proposition that "there is nothing within Krause that

suggests that Krause's technique must only be applied to sub-regions within an 8x8 block," the Board looked briefly at the difference between Krause's claim 1, which does not mention regions, and claim 2, which does. (Appx0007.) Based on that, the Board "conclude[d] that claim 1 of Krause does not require division of the block into a plurality of regions." (*Id.*)

That unremarkable observation does nothing to support the idea that Krause anticipates claims of the '071 patent. For one thing, an assertion about what claim 1 does *not* require or disclose is not a finding about what it *does* disclose—which is what matters for anticipation. *See, e.g., Net MoneyIn*, 545 F.3d at 1369-71. And the mere fact that Krause's claim 1 does not recite dividing the block into regions does not mean that it *also* discloses a single-entity transmission of *all* non-zero coefficients in that block. It just means that the block is not divided into regions.

Even beyond that, the Board's invocation of claim differentiation is wrong on its own terms, for proper application of that doctrine actually shows why claim 1 does not disclose or recite AT&T's invention. "The doctrine of claim differentiation creates a presumption that distinct claims, particularly an independent claim and its dependent claim, have different scopes." *World Class Tech. Corp. v. Ormco Corp.*, 769 F.3d 1120, 1125 (Fed. Cir. 2014). That is critical because Krause's claim 2 depends from claim 1:

> 1. A method for coding video transform coefficients for communication comprising the steps of:

providing a block of transform coefficients;

generating a vector to identify locations of a group of coefficients from said block that qualify for transmission according to predetermined criteria;

encoding said vector to provide a vector code word for transmission; and

encoding the coefficients from said group to provide coefficient code words for transmission;

wherein said vector code word correlates the coefficient code words to coefficient locations in said block.

2. A coding method in accordance with claim 1 comprising the further step of:

dividing said block into a plurality of regions containing subsets of coefficients, said vector identifying a group of coefficients that qualify for transmission in a first one of said regions; and

generating additional vectors for encoding to identify locations of groups of coefficients that qualify for transmission in other regions of said block.

(Appx0051(11:36-58).)

Context—from the claims and the specification—undermines the Board's curt assertion about these claims. As AT&T explained to the Board, Krause uses the terms "group" and "subset" interchangeably throughout the patent. (Appx2130-31.) Claim 1's reference to a "group of coefficients" qualified for transmission is thus properly read to claim a method for identifying some, but not all, of the coefficients qualified for transmission in a block. That method could theoretically be performed more than once to transmit all data for the entire block, but reading it to refer to all coefficients being transmitted for the entire block in one swoop is inconsistent with the claim language and ignores the overall

disclosure of Krause, which focuses on, specifically describes, and teaches that efficiency is achieved by encoding only portions of a block. *See VirnetX, Inc. v. Cisco Sys., Inc.*, 767 F.3d 1308, 1317-18 (Fed. Cir. 2014) (emphasizing importance of entire disclosure and consistent teachings in claim construction).

And here is where claim differentiation comes in. Dependent claim 2 *narrows* independent claim 1 by specifying that the block is subdivided into specific regions and multiple vectors are generated for multiple regions. In other words, claim 1 covers the concept of coding a group of—*i.e.*, fewer than all—non-zero coefficients in a block and generating a vector for at least that one group without limiting how the group is defined or organized, and claim 2 covers a specific method of dividing a block to group the coefficients into particular regions and generating vectors for each of those regions. If claim 1 were read, as the Board seemed to read it, to recite a single vector for a single group consisting of *all* non-zero coefficients in the entire block, then claim 2 would not properly depend from claim 1. Rather, claim 2 would recite a different invention for transmitting an entire block of transform coefficients using multiple vectors, neither narrower nor broader than claim 1. That is inconsistent with claim differentiation principles. *See, e.g.*, *World Class Tech.*, 769 F.3d at 1125.

In sum, the Board's conclusion that Krause's claim 1 "does not require" dividing a block into regions does not support the finding that Krause anticipates

any claims of the '071 patent. Both points on which the Board's decision rests are thus unsupported, and its decision should be reversed.

III. AT A MINIMUM, THE BOARD'S DECISION AFFIRMING THE EXAMINER'S HAPHAZARD REJECTIONS SHOULD BE VACATED AND REMANDED.

This Court has long recognized that, on the one hand, the PTO may use certain procedural devices to facilitate its review of patentability questions but that, on the other hand, it must ensure that patent owners receive a fair shake. This case implicates questions regarding both of these competing considerations: whether the PTO ever articulated a valid *prima facie* anticipation rejection and, even if it did, whether AT&T had a fair opportunity to rebut it. The answer to both is no. If the Court does not reverse the Board's decision outright, therefore, it should at least vacate and remand.

A. The PTO Never Articulated A Valid *Prima Facie* Anticipation Rejection.

It is well settled that the PTO in reexamination proceedings may rely on the procedural device of burden-shifting through a *prima facie* showing. That is, "the first body to raise a particular ground for rejection[] bears the initial burden … of presenting a prima facie case of unpatentability…. Once the examiner or Board carries th[at] burden …, the burden of coming forward with evidence or argument shifts to the [patent owner]." *In re Alton*, 76 F.3d 1168, 1175 (Fed. Cir. 1996) (first omission in original). In trying to assemble even a *prima facie* case,

however, ordinary anticipation principles still apply, including the need for clear disclosure and the corollary that "an anticipation rejection cannot be predicated on an ambiguous reference." *Application of Turlay*, 304 F.2d 893, 899 (C.C.P.A. 1962); *see also, e.g.*, *W.L. Gore & Assocs., Inc. v. Garlock, Inc.*, 721 F.2d 1540, 1554 (Fed. Cir. 1983) (prior art teachings were "so unacceptably vague … as not to support an anticipation rejection").

For the reasons stated above, *supra* § II, the PTO never articulated a *prima facie* anticipation rejection that could properly shift the burden to AT&T. The Board proceeded as if it had, discussing only AT&T's arguments in response to the rejections without ever articulating or adopting any precise bases for those rejections. (Appx0001-8.) And even the examiner's assertions standing alone did not justify a shift of the burden to AT&T. When a piece of prior art "can be alternatively interpreted to show either of two [disclosures], then [it] becomes an ambiguous reference which will not support an anticipation rejection." *Application of Hughes*, 345 F.2d 184, 188 (C.C.P.A. 1965). The examiner's inferences about Krause's applicability to an entire block (Appx2097) reveal, at a minimum, that what Krause discloses and means is ambiguous. The burden should have never shifted to AT&T, and neither the PTO nor the Board ever articulated a sound reason why it did. That is grounds for reversal, *infra* § II. Alternatively, it is at least grounds for vacatur and remand. *See, e.g.*, *Ariosa Diagnostics v. Verinata*

Health, Inc., 805 F.3d 1359, 1366 (Fed. Cir. 2015) (vacating and remanding where "the Board did not sufficiently articulate the … grounds" for its decision).

B. Even If The Court Finds That The PTO Presented A *Prima Facie* Anticipation Rejection, AT&T Did Not Have A Fair Opportunity To Rebut It.

Even if the Court thinks the Board was right to presume the examiner had presented a valid *prima facie* anticipation rejection—and, again, for all of the reasons stated above, it should not—the Court still should vacate and remand to the PTO to give AT&T a fair and proper opportunity to respond to the finally-settled-upon rejection.

This Court has often stated that patent owners are "undoubtedly entitled to notice of and a fair opportunity to meet the grounds of rejection." *Dell Inc. v. Acceleron, LLC*, 818 F.3d 1293, 1301 (Fed. Cir. 2016). The PTO cannot therefore "change theories in midstream," such that the ground for decision takes awhile before it "eventually materialize[s]," without "reasonable notice" and the "opportunity" to argue against that theory. *SAS Inst., Inc. v. ComplementSoft, LLC.*, No. 2015-1346, 2016 WL 3213103, at *7 (Fed. Cir. June 10, 2016). The necessary "fair opportunity" has been characterized as requiring a "fair opportunity to react to the thrust of the rejection." *In re Biedermann*, 733 F.3d 329, 337 (Fed. Cir. 2013); *see also Hughes*, 345 F.2d at 185-86.

Even assuming that the PTO had the authority to initiate this *inter partes* reexamination—and, as shown above, it did not—AT&T never got that fair opportunity because of the peculiar way in which this proceeding unfolded. The ground for rejection presented in LG's request was abandoned by LG as meritless, a position with which the examiner ultimately agreed. The theory to which the examiner (and the Board) then retreated was stated as a rejection *for the first time* in the notice of right to appeal. (Appx2088-99.) At that point, however, reexamination proceedings were effectively over. This hampered AT&T's ability to respond in several critical respects.

First, it rendered the earlier interview with the examiner essentially pointless. After LG dropped out, the PTO granted AT&T's request for an interview. (Appx2002-07.) But the interview took place in January 2014, *before* the examiner switched from a theory about Krause's regions to a theory about the entire block. (Appx2014-29; Appx2088-89.) Although AT&T thought (and was told) that the interview cleared up any outstanding concerns the examiner had about the rejection as then articulated (Appx2034-38), it turns out that the interview focused entirely on a now-discarded rejection and served no purpose. That was not a fair opportunity for AT&T to address a theory that had not yet been formulated.

Second, the PTO never had to provide a meaningful response to AT&T's contention that Krause is not enabling for a single vector specifying all coefficients in a block. "Once an applicant makes a non-frivolous argument that cited prior art is not enabling, … the examiner must address that challenge." *In re Morsa*, 713 F.3d 104, 110 (Fed. Cir. 2013). AT&T made that showing (Appx2073-75), but the examiner's "response" was entirely lacking (Appx2091-92). In particular, the examiner stated in one sentence that Krause "is considered to be enabled since [it] teaches that in the case of encoding an entire 8x8 block, the encoder must be capable of encoding 2^{64} possible combinations of coefficients." (Appx2091-92.) But stating what an encoder "must be capable of" does not demonstrate how one of skill in the art would have been enabled to generate that capability. *See, e.g.*, *Morsa*, 713 F.3d at 110 ("must assess the enabling nature of a prior art reference in light of the proposed claims"). The PTO thus failed to show that Krause enables the alleged disclosure it erroneously pieced together from scattered bits of Krause.

Third, there was no evidence, and particularly no expert testimony, addressing what Krause does—or, more accurately, does not—disclose to one of ordinary skill in the art. "Typically, testimony concerning anticipation must be testimony from one skilled in the art and must identify each claim element, state the witnesses' interpretation of the claim element, and explain in detail how each claim element is disclosed in the prior art reference." *Dayco Prods., Inc. v. Total*

Containment, Inc., 329 F.3d 1358, 1369 (Fed. Cir. 2003); *see also Schumer v. Lab. Computer Sys., Inc.*, 308 F.3d 1304, 1315-16 (Fed. Cir. 2002) (same). Such testimony is an ordinary part of adversarial reexamination, developed and presented early on. But that usual course of action was never in play in these proceedings, where LG had dropped out and the actual basis for rejection—and the reading of Krause on which it rests—was not presented until the proceedings were essentially completed.

In sum, even assuming that this *inter partes* reexamination was properly initiated, it strayed far from the ordinary and appropriate nature of such proceedings. The consequence was a series of unsupported rejections that should be reversed. If they are not, however, the rejections should be vacated and remanded so that AT&T may have a chance to contest them in the proper and ordinary (and orderly) manner.

CONCLUSION

For the foregoing reasons, the Court should reverse the decision rejecting claims 1, 3, 9, 10, 12, 21, 22, 31, and 32 of the '071 patent or, at a minimum, vacate and remand.

Dated: July 13, 2016

Respectfully submitted,

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ADDENDUM

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LG ELECTRONICS, INC.
Requester

v.

AT&T INTELLECTUAL PROPERTY II, L.P.
Patent Owner and Appellant

Appeal 2015-007847
Reexamination Control 95/002,353
Patent US 7,454,071 B2
Technology Center 3900

Before RICHARD M. LEBOVITZ, JEFFERY B. ROBERTSON, and ANDREW J.DILLON, *Administrative Patent Judges*.

DILLON, *Administrative Patent Judge*.

DECISION ON APPEAL

STATEMENT OF THE CASE

Owner appeals under 35 U.S.C. § 134(b) (2002) from the final decision of the Examiner adverse to the patentability of claims 1, 3, 9, 10, 12, 21, 22, 31, and 32.

We have jurisdiction under 35 U.S.C. § 315 (2002).

We heard oral argument in this Appeal on December 7, 2015, a transcript of which will be entered into the electronic record in due course.

We affirm.

Invention

The '353 patent describes a method of using pattern vectors for image coding and decoding. The method comprises converting a block of image data into a set of transform coefficients, quantizing the transform coefficients such that a number of the coefficients become zero, constructing a single entity or bit vector indicating which coefficients are non-zero, coding the single entity or bit vector as an integer using an adaptive, semi-adaptive or nonadaptive arithmetic coder, coding the values of the coefficients in any fixed order, using an adaptive, semi-adaptive or non-adaptive arithmetic coder, or some other coder, and coding all coefficients except the zero coefficients. Abstract.

Claims

Claims 1, 3, 9, 10, 12, 21, 22, 31, and 32 are subject to reexamination and have been rejected. Claims 1-35 are original patent claims. Claims 4 and 13 have been canceled. Claims 1, 10, 21, and 31 are independent.

Claim 1 is illustrative.

1. A method for identifying non-zero coefficients in a square block of image data, the method comprising:

mapping a square block of transform coefficients into a one-dimensional list of transform coefficients in a fixed order;

generating a single entity that identifies which transform coefficients in the one dimensional list are non-zero; and

coding the single entity.

Prior Art

Meeker	US 5,740,283	Apr. 14, 1998
Krause	US 5,295,203	Mar. 15, 1994

Wenye Yang and Jerry D. Gibson, "Coefficient Rate and Significance Maps in Transform Coding," Conference Record of the Thirty-First Asilomar Conference on Signals, Systems & Computers, Vol. 2, pp. 1373-1377, November 2-5,1997 (hereinafter "Yang");

Vivek K. Goyal, "Theoretical Foundations of Transform Coding," IEEE Signal Processing Magazine, pp. 9-21, September 2001 (hereinafter "Goyal");

Henrique S. Malvar, "Lapped Biorthogonal Transforms for Transform Coding with Reduced Blocking and Ringing Artifacts," Presented at the IEEE ICASSP Conference, Munich, April 1997 (hereinafter, "Malvar").

Owner's Contentions

Owner contends that the Examiner erred in entering the following grounds of rejections:

A. The rejection of claims 1, 3, 9, 21, and 22 under 35 U.S.C. § 102(b) as being anticipated by Krause; (App. Br 8-23)

B. The rejection of claims 10, 12, 31, and 32 under 35 U.S.C. § 103(a) as being unpatentable over Krause and Meeker; (App. Br. 23-25).

Representative Claim

Owner relies on the limitations of claim 1 and does not provide substantive arguments for separate patentability for any other claim. Accordingly, we will decide the appeal on the basis of claim 1 alone. *See* 37 C.F.R. § 41.67(c)(1)(vii).

Owner argues independent claim 1 is not anticipated by Krause in view of the failure of Krause to disclose mapping "a square block of transform coefficients into a one-dimensional list of transform coefficients" and generating "a single entity" that identifies which transform coefficients "in the one-dimensional list" are not zero. App. Br. 8.

Initially, Owner argues that the Examiner erred in rejecting claim 1, by utilizing a faulty interpretation of the claimed "block," that is, ignoring the express description of the claimed "block" as a "square" block. Owner cites the Examiner's comments at page 7 of the RAN, wherein the Examiner indicated an intention to interpret the term "block" as including any shape. App. Br. 9.

In response, the Examiner notes that the cited rejection set forth at page 7 of the RAN was asserted against original claim 1, which merely recited "blocks." The Examiner then notes that the amended claim is rejected in view of the disclosure within Krause that the encoding process could be applied to 8x8 square blocks of image data. Ans. 4.

Consequently, we find the Examiner did not apply a faulty interpretation of the term "block," as asserted by Owner.

Next, Owner asserts the Examiner's anticipation rejection includes an "*acknowledged* erroneous factual finding," citing the Examiner's prior acknowledgment that the irregular shaped regions 40, 42, 44, and 47 of Krause do not correspond to the claimed square block of transform coefficients. App. Br. 9-12.

The Examiner responds by acknowledging that the "preferred" embodiment of Krause does indeed disclose utilizing subregions of a square block of transform coefficients, but notes that Krause also describes the processing of an entire block of transform coefficients at Column 7, line 58 through Column 8, line 3, which the Examiner interprets as a 'non-preferred" embodiment. Ans. 5.

Owner argues that the claimed invention is addressed to the processing of an entire block of transform coefficients and that invention is not disclosed by Krause. Owner characterizes Krause's description of the cumbersome nature of processing an entire block of transform coefficients as a description of the state of the art and a reason why it is desirable to reduce the size of the region that is vector coded. Reb. Br. 5-6.

We find the cited portion of Krause at Column 7, line 58 through Column 8, line 3, to be an express acknowledgement that the calculation of all possible combinations of coefficients which are non-zero within an entire block, while "not easy," was contemplated in the prior art. We further find that Krause teaches generating a "single entity" (vector 60) "that identifies which transform coefficients in the one-dimensional list are non-zero" within a particular region, and that teaching was appropriately appreciated by the Examiner to include the calculation of all possible combinations of coefficients which are non-zero within an entire block. (Krause, col. 8, ll. 39-64.)

It is well settled that "[T]he use of patents as references is not limited to what the patentees describe as their own inventions or to the problems with which they are concerned. They are part of the literature of the art, relevant for all they contain." *In re Heck*, 699 F.2d 1331, 1332-33, 216 USPQ 1038, 1039 (Fed. Cir. 1983) (quoting *In re Lemelson*, 397 F.2d 1006, 1009, 158 USPQ 275, 277 (CCPA 1968)).

Consequently we are not persuaded by Owner's arguments that assert the cited portion of Krause is not an "embodiment" and should not be considered. We find no erroneous factual finding by the Examiner.

Owner also argues that the "totality of Krause's disclosure" fails to support the non-preferred embodiment cited by the Examiner, noting that claims 1 and 2 of Krause are directed to the broad concept and illustrated embodiment respectively. App. Br. 17-20.

The Examiner finds that the encoding of an entire 8x8 block of image data is not preferred because it is "computationally complex." Further, the

Examiner finds there is nothing within Krause that suggests that Krause's technique must only be applied to sub-regions within an 8x8 block. Ans. 7-8.

We concur with the Examiner for the reasons we set forth above. As evidence thereof we note claim 1 of Krause sets forth expressly the creation of a vector identifying locations of a group of coefficients from a block, not a merely a region of that block. Further, claim 2 expressly sets forth dividing the block up into a plurality of regions. Under the well-established doctrine of claim differentiation, we conclude that claim 1 of Krause does not require division of the block into a plurality of regions.

"[T]he presence of a dependent claim that adds a particular limitation raises a presumption that the limitation in question is not found in the independent claim." *Liebel-Flarsheim Co. v. Medrad, Inc.*, 358 F.3d 898, 910 (Fed.Cir.2004).

Owner argues the non-anticipation of claims 3, 9, 12, and 22 based upon the arguments set forth above. App. Br. 22-23.

For the reasons we set forth above we find the Examiner's position with regard to the anticipation of these claims by Krause to be persuasive.

With regard to the Examiner's rejection of claims 10, 12, 31, and 32 under 35 U.S.C. § 103(a) as being unpatentable over Krause and Meeker, Owner argues that these claims are directed toward computer readable medium, noting that the Examiner merely cited Meeker to demonstrate that it was notoriously well-known at the time of the invention to utilize software as a preferred means of implementing video codecs. With regard to patentability, Owner reiterates the arguments set forth above regarding

alleged errors by the Examiner regarding claim construction and factual findings.

For the reasons we set forth above with regard to claim 1, we find no error in the Examiner's position with regard to the rejection of claims 10, 12, 31, and 32.

DECISION

The Examiner's decision adverse to the patentability of claims 1, 3, 9, 10, 12, 21, 22, 31, and 32 is affirmed.

Requests for extensions of time in this proceeding are governed by 37 C.F.R. §§ 1.956 and 41.79(e).

AFFIRMED

Patent Owner:

AT&T LEGAL DEPARTMENT - GB
ATTN: PATENT DOCKETING
ROOM 2A-207
ONE AT&TWAY
BEDMINSTER, NJ 07921

Third Party Requester:

LEE, HONG, DEGERMAN, KANG & WAIMEY
600 S. FIGUEROA STREET
SUITE 2300
LOS ANGELES, CA 90017

US007454071B2

(12) **United States Patent**
Howard

(10) **Patent No.: US 7,454,071 B2**
(45) **Date of Patent: *Nov. 18, 2008**

(54) **SYSTEM AND METHOD FOR USING PATTERN VECTORS FOR VIDEO AND IMAGE CODING AND DECODING**

(75) Inventor: **Paul Glor Howard**, Morganville, NJ (US)

(73) Assignee: **AT&T Intellectual Property II, L.P.**, New York, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/684,841**

(22) Filed: **Mar. 12, 2007**

(65) **Prior Publication Data**

US 2007/0154090 A1 Jul. 5, 2007

Related U.S. Application Data

(63) Continuation of application No. 10/086,102, filed on Feb. 28, 2002, now Pat. No. 7,206,448.

(51) **Int. Cl.**
G06K 9/36 (2006.01)
G06K 9/46 (2006.01)

(52) **U.S. Cl.** **382/232**; 382/233; 382/250; 382/251; 382/248; 382/247; 375/240.03; 375/240.23

(58) **Field of Classification Search** 382/232, 382/245, 246, 247, 248, 239, 250, 251, 170, 382/194; 375/240.03, 240.23; 348/395.1, 348/403.1, 404.1, 407.1, 408.1; 358/426.01, 358/426.07, 426.16
See application file for complete search history.

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Primary Examiner—Matthew C. Bella
Assistant Examiner—Ali Bayat

(57) **ABSTRACT**

An exemplary embodiment of the invention relates to a method of using pattern vectors for image coding and decoding. The method comprises converting a block of image data into a set of transform coefficients, quantizing the transform coefficients such that a number of the coefficients become zero, constructing a single entity or bit vector indicating which coefficients are non-zero, coding the single entity or bit vector as an integer using an adaptive, semi-adaptive or non-adaptive arithmetic coder, coding the values of the coefficients in any fixed order, using an adaptive, semi-adaptive or non-adaptive arithmetic coder, or some other coder, and coding all coefficients except the zero coefficients. The system and method of decoding data relate to the corresponding hardware and process steps performed by the decoder when decoding a bitstream coded as described herein.

35 Claims, 6 Drawing Sheets

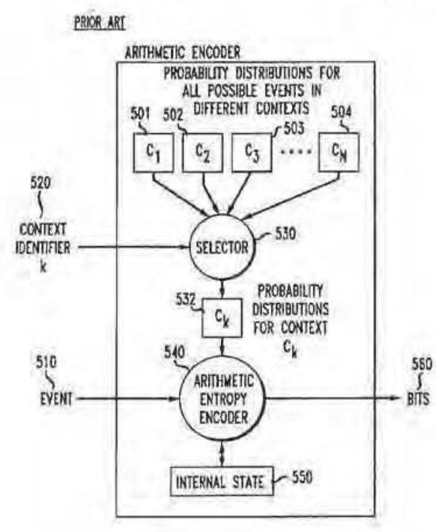

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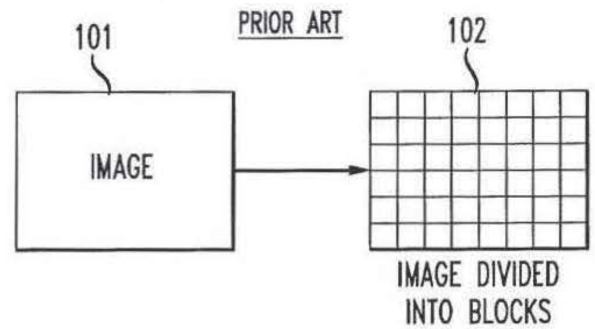
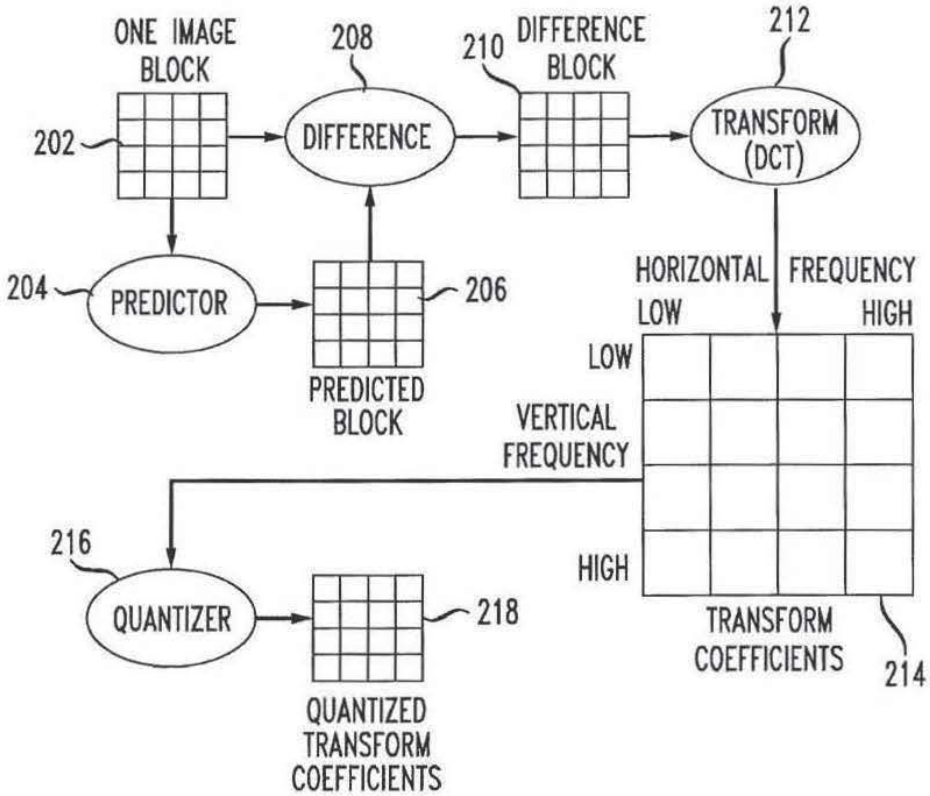
FIG. 1



PRIOR ART
101
102
IMAGE
IMAGE DIVIDED INTO BLOCKS

FIG. 2



ONE IMAGE BLOCK
202
208
DIFFERENCE
210
DIFFERENCE BLOCK
212
TRANSFORM (DCT)
204
PREDICTOR
206
PREDICTED BLOCK
HORIZONTAL FREQUENCY
LOW
HIGH
LOW
VERTICAL FREQUENCY
HIGH
TRANSFORM COEFFICIENTS
214
216
QUANTIZER
218
QUANTIZED TRANSFORM COEFFICIENTS

FIG. 3

PRIOR ART

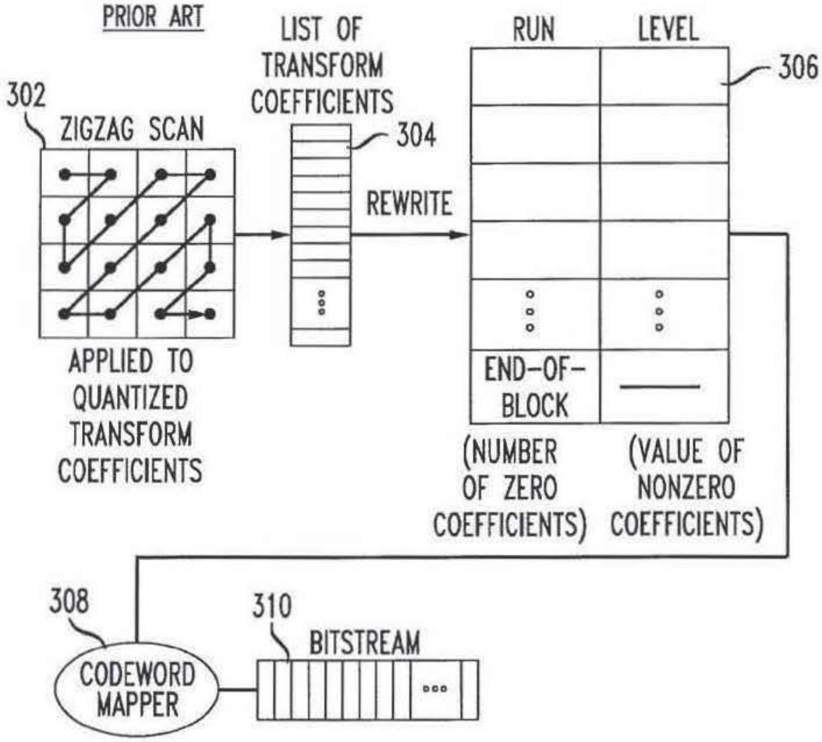


FIG. 4

PRIOR ART

402 404 406 408

RUN, LEVEL	CODEWORD
END-OF-BLOCK	0
(0,1)	100
(0,−1)	101
(1,1)	11000
(1,−1)	11001
(0,2)	11010
(0,−2)	11011
(2,1)	1110000
⋮	⋮

FIG. 5
PRIOR ART

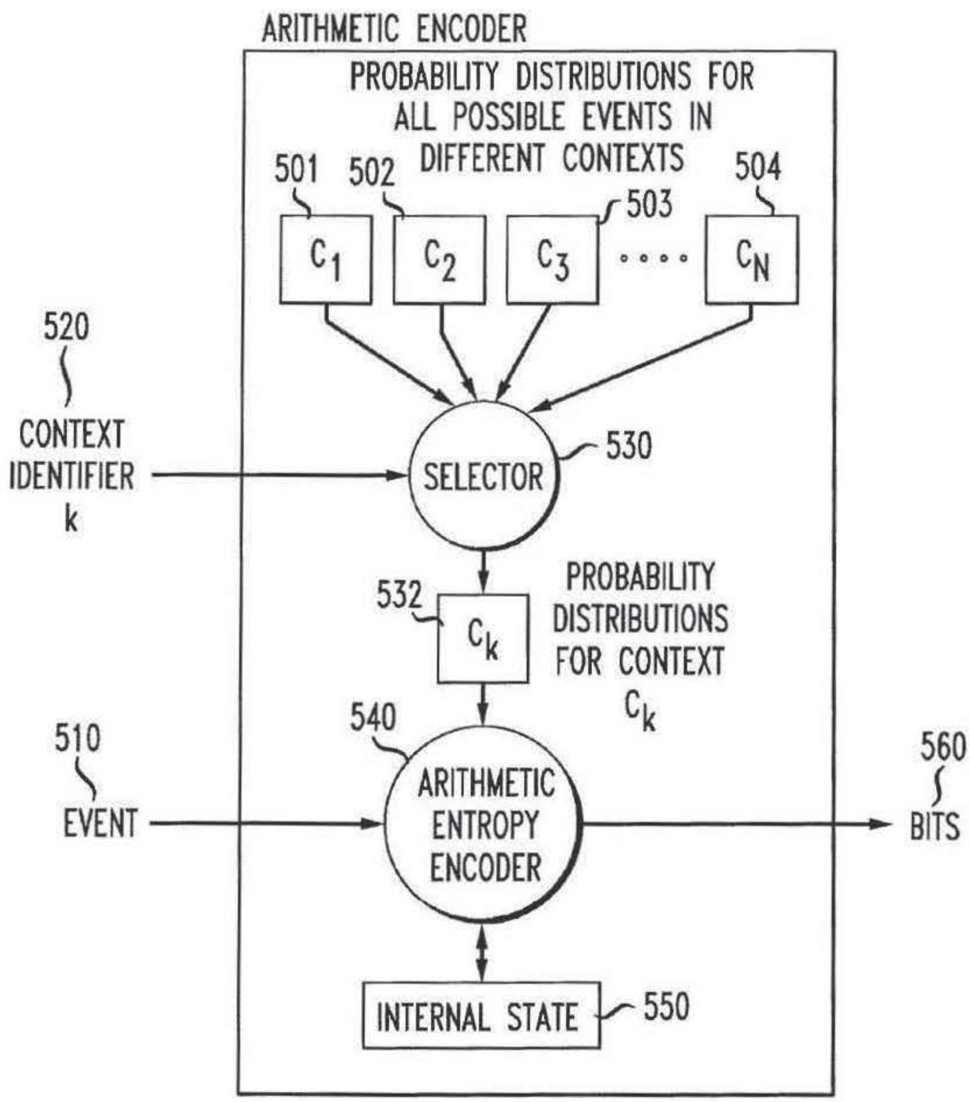


FIG. 6

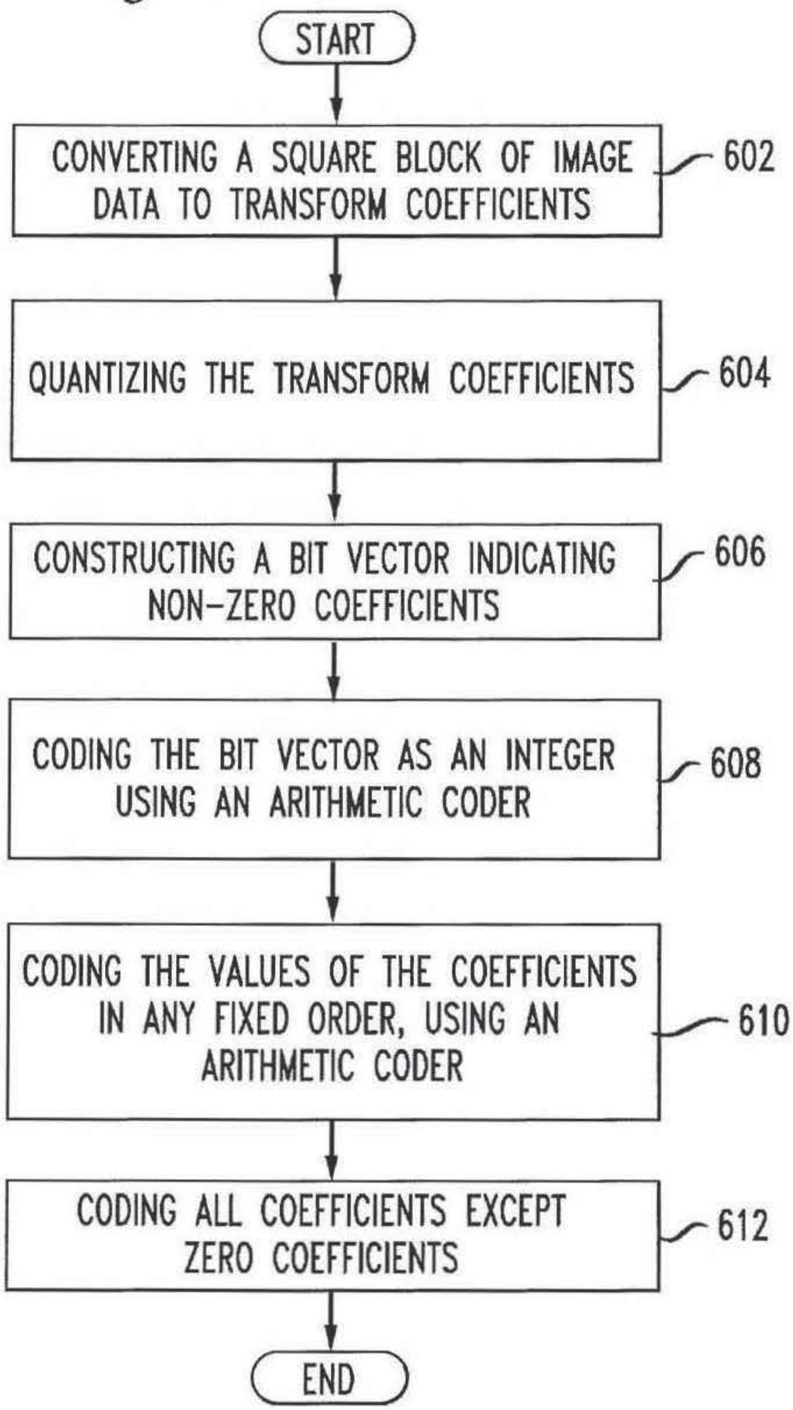

START
CONVERTING A SQUARE BLOCK OF IMAGE DATA TO TRANSFORM COEFFICIENTS
602
QUANTIZING THE TRANSFORM COEFFICIENTS
604
CONSTRUCTING A BIT VECTOR INDICATING NON-ZERO COEFFICIENTS
606
CODING THE BIT VECTOR AS AN INTEGER USING AN ARITHMETIC CODER
608
CODING THE VALUES OF THE COEFFICIENTS IN ANY FIXED ORDER, USING AN ARITHMETIC CODER
610
CODING ALL COEFFICIENTS EXCEPT ZERO COEFFICIENTS
612
END

FIG. 7

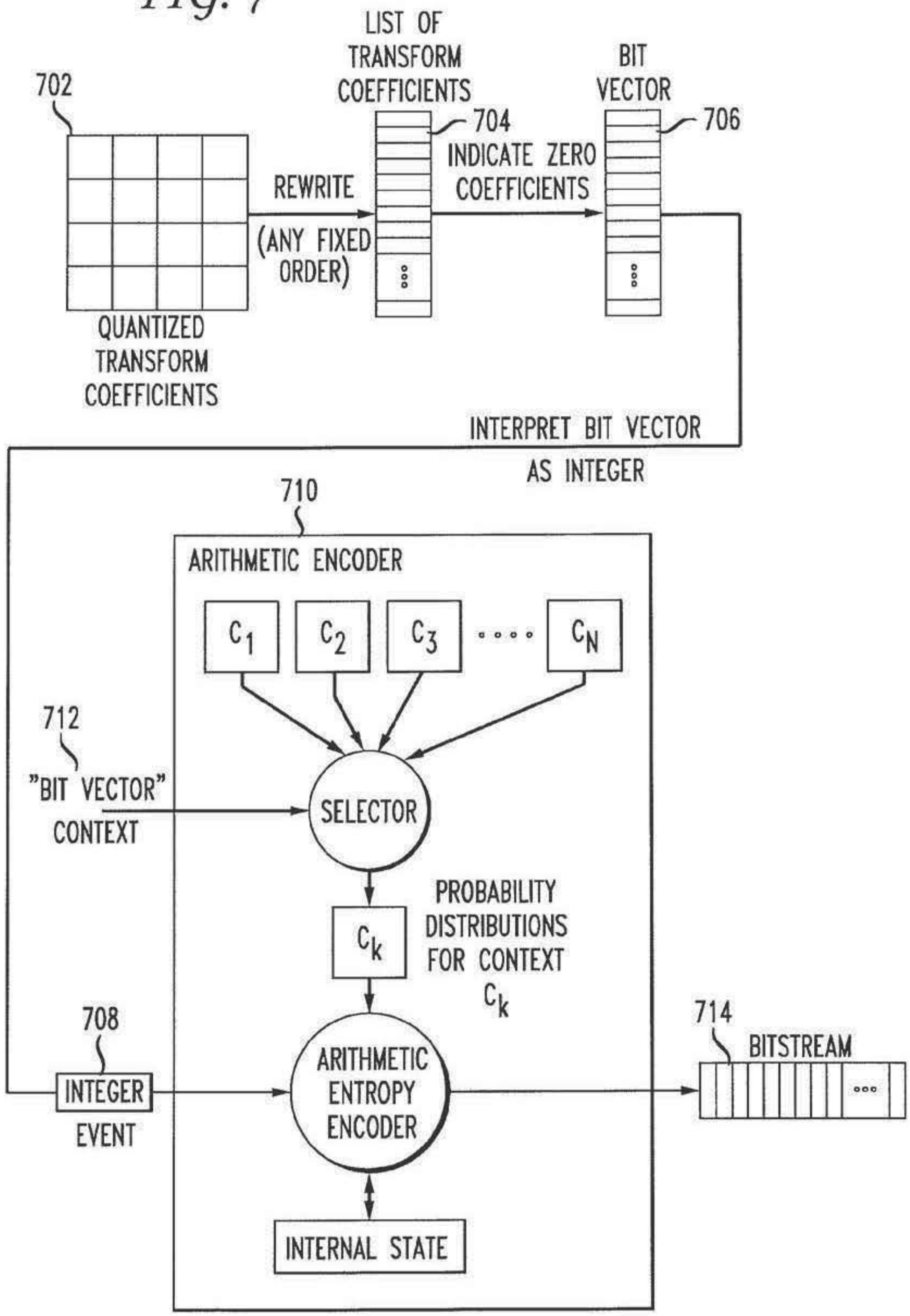

702
LIST OF TRANSFORM COEFFICIENTS
704
BIT VECTOR
706
REWRITE
(ANY FIXED ORDER)
INDICATE ZERO COEFFICIENTS
QUANTIZED TRANSFORM COEFFICIENTS
INTERPRET BIT VECTOR AS INTEGER
710
ARITHMETIC ENCODER
C_1
C_2
C_3
C_N
712
"BIT VECTOR" CONTEXT
SELECTOR
C_k
PROBABILITY DISTRIBUTIONS FOR CONTEXT C_k
708
INTEGER
EVENT
ARITHMETIC ENTROPY ENCODER
714
BITSTREAM
INTERNAL STATE

FIG. 8

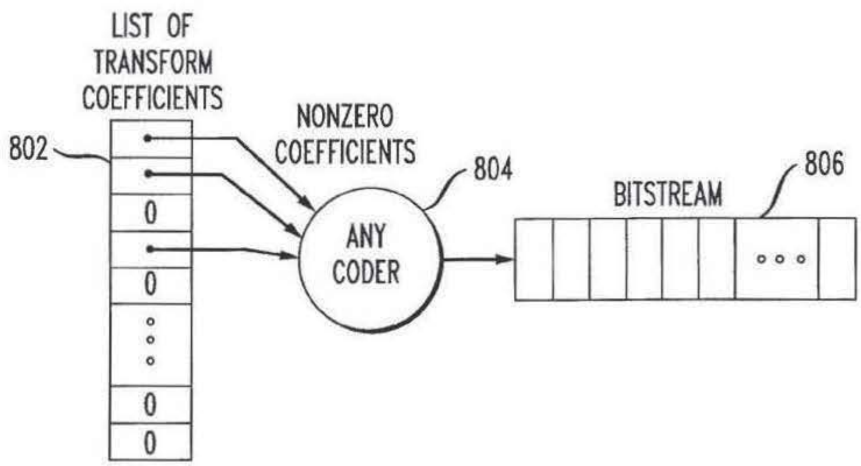
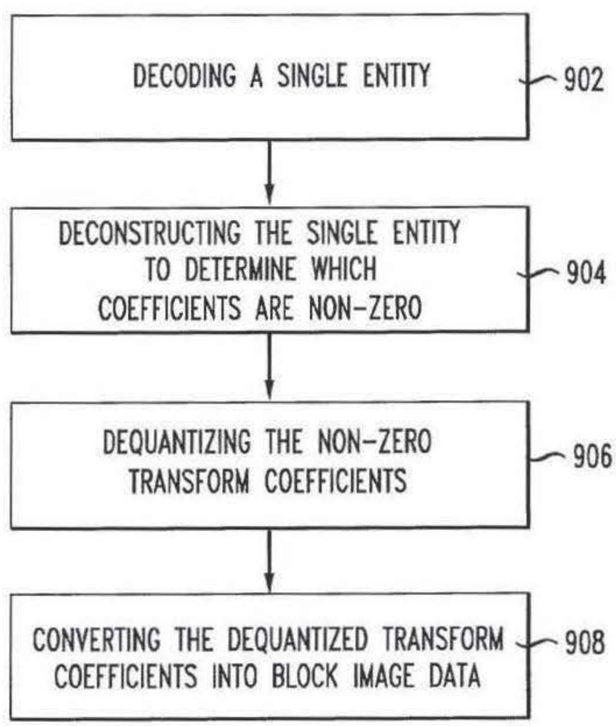

LIST OF TRANSFORM COEFFICIENTS
802
0
0
0
0
NONZERO COEFFICIENTS
804
ANY CODER
BITSTREAM
806

FIG. 9


DECODING A SINGLE ENTITY
902
DECONSTRUCTING THE SINGLE ENTITY TO DETERMINE WHICH COEFFICIENTS ARE NON-ZERO
904
DEQUANTIZING THE NON-ZERO TRANSFORM COEFFICIENTS
906
CONVERTING THE DEQUANTIZED TRANSFORM COEFFICIENTS INTO BLOCK IMAGE DATA
908

SYSTEM AND METHOD FOR USING PATTERN VECTORS FOR VIDEO AND IMAGE CODING AND DECODING

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a system and method of video compression coding and decoding and particularly to a system and method of using pattern vectors for video and image coding and decoding that eliminates two-dimensional coding of transform coefficients and the requisite zigzag scan order or alternate scan order.

2. Discussion of Related Art

Transform coding is the heart of several industry standards for image and video compression. Transform coding compresses image data by representing samples of an original signal with an equal number of transform coefficients. A sample of the original signal may be the signal itself, or it may be the difference between the signal and a predicted value of the signal, the prediction being done by any of a number of widely-known methods. Transform coding exploits the fact that for typical images a large amount of signal energy is concentrated in a small number of coefficients. Then only the coefficients with significant energy need to be coded. The discrete cosine transform (DCT) is adopted in standards such as the Joint Photographers Expert Group (JPEG) image coding standard, Motion Picture Expert Group (MPEG) video coding standards, ITU-T recommendations H.261 and H.263 for visual telephony, and many other commercially available compression systems based on some variations of these standard transform coding schemes.

Transform coding is a block-based image compression technique in which the input image is partitioned into fixed-size small blocks and each block of pixels is coded independently. FIG. **1**, FIG. **2**, and FIG. **3** illustrate a standard method of block-based image compression. As shown in FIG. **1**, in a typical transform encoder, an input image (**101**) is partitioned into blocks (**102**). The blocks are usually square but may be of any rectangular shape, or in fact may be of any shape at all. FIG. **2** illustrates the data **202** in a block is transformed by a sequence of linear operations in the encoder into a set of quantized transform coefficients. A predictor **204** may predict the sample values in the block to yield a predicted block **206**. Many such predictors are known in the art. A difference operator **208** computes a difference block **210** representing a difference between the image data **202** and the prediction block **206**. A transform operator **212** transforms the difference block **210**, typically a discrete cosine transform (DCT), into a set of transform coefficients **214**.

If the input block is rectangular, the set of transform coefficients form a rectangular array. The transform coefficients y_k, $1 \leqq k \leqq K$, are quantized independently by distinct quantizers **216** to generate a set of indices, referred to as the quantized transform coefficients **218**.

FIG. **3** shows that the indices are converted by a predetermined scan order **302**, typically one that zigzags through the quantized transform coefficients in increasing frequency order, to produce a list of transform coefficients **304**. The list of transform coefficients is rewritten as a set of (run, level) pairs **306**. The "run" component of each pair is the count of the number of zero coefficients before the next nonzero coefficient; the "level" component is the value of the next nonzero coefficient. The (run, level) pairs are mapped by a codeword mapper **308** into a sequence of bits **310** that are output to the channel to be transmitted to the decoder.

FIG. **4**. shows part of an example mapping between (run, level) pairs **402** and codewords **404**. One codeword **406** is reserved to indicate that there are no more nonzero coefficients in the block, i.e., to indicate the end-of-block condition **408**.

As shown in FIGS. **2** and **3**, the basic process for transform coding includes the following steps: converting a block of image data into an array of transform coefficients (**214**); quantizing the transform coefficients such that all, some, or none of the coefficients become zero; the zero coefficients are typically the high-frequency coefficients (**218**); ordering the coefficients in a list according to a fixed order, typically in a zigzag scan ranging over the coefficients from low to high frequency in both the horizontal and vertical dimensions, so that the zero high-frequency) coefficients tend to be clustered at the end of the list (**302**); coding the list of coefficients as a sequence of (run, level) pairs (**306**); assigning a codeword to each pair according to a code such as a Huffman code (**308**); and using a single reserved codeword to signify the "end of block" condition, that is, the condition that all nonzero coefficients in the block have already been coded (**406**,**408**).

The run component of each pair is the length of a run of zero coefficients in the coefficient ordering, and the level is the actual value of the next nonzero coefficient. Each possible (run, level) pair is mapped by a fixed, previously determined mapping to a codeword based on a variable length prefix-free code (e.g., a Huffman code). One codeword **406** of the code is reserved for the "end-of-block" indicator **408**, meaning that there are no more nonzero coefficients in the block.

There are deficiencies in transform coding. The method requires careful tuning of the coder. The following entities need to be carefully designed and matched to each other: (1) the coefficient ordering; (2) the variable length code; and (3) the matching of (run, level) pairs and the end-of-block condition to codewords. In addition, related coding schemes fail to take advantage of correlations between coefficients other than those implied by the fixed coefficient ordering. Further, the use of prefix-free codes means that some compression inefficiency is inevitable.

Next, this disclosure discusses arithmetic coding with reference to FIG. **5** Arithmetic coding is a method of coding according to which a sequence of events, each with its own probability distribution, is coded, each event using the smallest number of bits theoretically possible given the probability of the event. This number of bits is not restricted to being an integer. An arithmetic coder retains state information between events, and makes use of this state information to allow coding multiple events with a single bit, and to allow the coding for a single event to extend over one or more full or partial bits.

FIG. **5** illustrates an example arithmetic encoder. The encoder contains probability distributions **501**, **502**, **503**, . . . , **504** for all possible events that can occur in different contexts C_1, C_2, C_3, . . . , C_N. An event **510** is input to the coder, along with its associated context identifier **520**. A selector **530** selects one of the stored probability distributions **532** based on the context identifier. The arithmetic entropy coder **540** transforms the event, the selected probability distribution, and the internal state of the arithmetic coder **550** into a sequence of bits **560** to be output to the channel for transmission to the decoder. The internal state **550** and the selected probability distribution are updated.

A theoretical arithmetic coder uses unlimited precision arithmetic, and is not practical. In the related art there are a number of "approximate arithmetic coders." These are approximate in the sense that the number of output bits is nearly theoretically optimal, but not exactly so. The result of

coding and decoding is a complete and exact reconstruction of the original sequence of events; it is not "approximate" in any sense. The term "arithmetic coding" invariably refers to use of an approximate arithmetic coder.

Many approximate arithmetic coders are designed to code binary events, that is, events that can have one of only two possible values. It is a trivial and obvious use of a binary arithmetic coder to code non-binary events by decomposing the non-binary events into a sequence of binary decisions, each coded as a binary event by a binary arithmetic coder.

What is needed in the art is an improvement image coding and decoding.

SUMMARY OF THE INVENTION

What is needed in the art is a transform coding technique and transform decoding technique that do not have to be tuned for all possible images ahead of time. An adaptive arithmetic coder handles that requirement. Further improved coding and decoding efficiency may be achieved by removing the need for an end-of-block signal. These and other advantages are provided according to the present invention.

An exemplary embodiment of the invention relates to a method of using pattern vectors for image coding. A computer device performs the method, as will be understood by those of skill in the art. With reference to FIG. **6**, the method comprises converting a block of image data into an array of transform coefficients (**602**) and quantizing the transform coefficients such that all, some, or none of the coefficients become zero (**604**). The method for coding image data further comprises constructing a bit vector indicating which coefficients are non-zero (**606**), and coding the bit vector as an integer using an arithmetic coder (**608**). The step of coding the bit vector may be accomplished using an adaptive arithmetic coder, semi-adaptive arithmetic coder or a non-adaptive arithmetic coder. The computer device codes the values of the coefficients in any fixed order, using an adaptive, semi-adaptive, or non-adaptive arithmetic coder.

Another embodiment of the invention relates to a method of decoding a bitstream coded according to the above-mentioned method. This embodiment comprises a method of decoding coded data comprising: decoding a bit vector coded as an integer using an arithmetic decoder wherein the values of the transform coefficients are decoded in any fixed order, deconstructing the bit vector to determine which coefficients are non-zero, dequantizing the non-zero transform coefficients converting the dequantized transform coefficients into block image data.

The number of coefficients transformed to zero depends on the image block itself and the quantization step size. The coarser the quantization, that is, the larger the quantization step size, the more coefficients become 0 and the worse the reconstructed image looks. For typical images, the energy compaction properties of the DCT often cause the high frequency coefficients to be smaller than the low frequency coefficients. A typical image contains hundreds, or even thousands, of blocks, and a typical video segment contains tens of images every second. Effective compression depends on the fact that, on average, many of the transform coefficients for many of the blocks are zero, and can be transmitted with very few bits. The essence of the present invention is a new and better method of using a very small number of bits to indicate the zero coefficients.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing advantages of the present invention will be apparent from the following detailed description of several embodiments of the invention with reference to the corresponding accompanying drawings, in which:

FIG. **1** illustrates an operation of dividing an image into a group of blocks;

FIG. **2** illustrates a known sequence of operations in image and video coding to convert one block of an image or video frame into an array of quantized transform coefficients;

FIG. **3** illustrates a known method of converting an array of quantized transform coefficients for one block into part of a bitstream;

FIG. **4** illustrates an example of part of a mapping between (run, level) pairs and codewords from a prefix-free code;

FIG. **5** illustrates a known method for performing arithmetic encoding;

FIG. **6** illustrates a method of coding image data according to an embodiment of the present invention;

FIG. **7** illustrates an example method of coding zero transform coefficients according to the present invention;

FIG. **8** illustrates an example method of coding nonzero transform coefficients according to the present invention; and

FIG. **9** illustrates an example method of decoding a bitstream generated according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention may be understood with reference to FIG. **6**. FIG. **6** shows a sample method of using pattern vectors for image coding according to an aspect of the invention. The method may be performed by the hardware components known to those of skill in the art. The method comprises converting a block of image data into an array of transform coefficients (**602**) and quantizing the transform coefficients such that all, some or none of the coefficients become zero (**604**). The method further comprises constructing a bit vector indicating which coefficients are non-zero (**606**) and coding the bit vector as an integer using an adaptive, semi-adaptive or non-adaptive arithmetic coder (**608**). Those of skill in the art will be aware of such arithmetic coders. Here it is noted that although a bit vector is referenced, the core idea of the present invention does not necessarily require the use of a bit vector given that the invention's principle is that all the zero and non-zero coefficient information is combined into a single entity for coding. Any related data whose relationship is not clearly defined can be coded according to the principles of the present invention.

For example, in another aspect of the invention, a method of coding data not having a clearly defined relationship comprises converting the data into transform coefficients, quantizing the transform coefficients such that all, some or none of the transform coefficients become zero, constructing a single entity from the quantized transform coefficients, and coding the single entity using an arithmetic coder wherein the values of the transform coefficients are coded in any fixed order. One example of the single entity is the bit vector discussed herein, but other entities may also be used.

Next, the method comprises coding the values of the coefficients in any fixed order, using an adaptive, semi-adaptive or non-adaptive arithmetic coder, or any other coder (**610**). Each coefficient is coded according to its own context, possibly based on which coefficient it is and possibly based on other factors. The method includes coding all coefficients except the zero coefficients indicated above (**612**).

The novel steps of the invention are further illustrated in FIG. 7 and FIG. 8. FIG. 7 illustrates the construction and coding of the single entity or bit vector. Conceptually, a computer device rewrites the array of transform coefficients **702** as a list of transform coefficients **704**. The method according to the present invention will be operated on a computer device having a processor operating a program of instructions to perform the data coding operations disclosed herein. Any number of computer devices may be used and such various computer devices are known to those of skill in the art and thus not illustrated.

A bit vector **706** has the same number of bits as the number of coefficients in the transform coefficient list, and there is a one-to-one correspondence between coefficients in the coefficient list and bits in the single entity or bit vector. The bit vector thus represents a significance map for one-dimensional list **704** of transfrom coefficients. Setting each bit in the bit vector where the corresponding coefficient in the coefficient list is zero fills the bit vector. The bit vector is then reinterpreted as an integer **708**. An arithmetic coder **710** encodes the integer **708**, with the context being identified as the "bit vector" context **712**. The arithmetic coder outputs bits to a bitstream **714**. The arithmetic coder **710** is as described above and illustrated in FIG. 5.

The computer device codes the values of the nonzero coefficients in any fixed order, using any coder. The coder may be an adaptive, semi-adaptive or non-adaptive arithmetic coder, or it may be any other coder. If the coefficients are coded using an arithmetic coder, each coefficient is coded according to its own context, possibly based on which coefficient it is and possibly based on other factors. All coefficients are coded except the zero coefficients indicated by the bit vector described above. FIG. 8 illustrates the coding of nonzero coefficients. The nonzero coefficients form a list of transform coefficients **802** are coded using any coder **804**. The coder outputs bits to the bitstream **806**.

Other embodiments of the invention include a computer device for practicing the method, a computer-readable medium for instructing a compute device to practice the method of the invention, a bitstream created according to a method of the present invention, and a decoder and decoder process for decoding a bistream generated according to an embodiment of the present invention. FIG. 9 illustrates an example method for decoding a bitstream. The bistream in this example was generated according to the embodiments of the invention described herein for generating a bitstream. The decoding method comprises decoding a single entity, such as the bit vector, wherein the values of transform coefficients are decoded in any fixed order (**902**), deconstructing the single entity to determine which coefficients are non-zero (**904**), dequantizing the transform coefficients to determine whether all, some or none of the coefficients are zero (**906**), and converting the dequantized transform coefficients into block image data (**908**).

An advantage of the present invention includes enabling a mechanical tuning of the encoder ahead of time, if desired. The mechanism is to operate the coder on a range of typical images or video sequences to obtain typical probability distributions for all events that can be coded, then to build these typical distributions into the coder and decoder as part of their initialization sequences. Thus no human intervention is necessary in the tuning process.

Another advantage of this invention is that the arithmetic coder automatically detects correlations among the various coefficients through the adaptation of the bit vector probability distributions. In addition, using arithmetic coding guarantees that almost no bits are wasted simply because of the limitations of prefix-free codes. These and other advantages will be apparent to those of skill in the art.

Although the above description contains specific details, they should not be construed as limiting the claims in any way. Other configurations of the described embodiments of the invention are part of the scope of this invention. For example, the principles of the present invention may be applied to allow coding of any related data, not just image data. There are many uses of arithmetic coding beyond image and video coding to which the fundamental principles of the present invention do apply. Accordingly, the appended claims and their legal equivalents should only define the invention, rather than any specific examples given.

I claim:

1. A method for identifying non-zero coefficients in a block of image data, the method comprising:

mapping a block of transform coefficients into a one-dimensional list of transform coefficients in a fixed order;

generating a single entity that identifies which transform coefficients in the one-dimensional list are non-zero;and

coding the single entity.

2. The method of claim **1**, further comprising coding the single entity based at least in part on a context of the single entity.

3. The method of claim **1**, wherein the single entity is a bit vector.

4. The method of claim **1**, wherein the single entity and the transform coefficients organized in the fixed order have a one-to-one correspondence between the coefficients and bits in the single entity.

5. The method of claim **1** further comprising coding all non-zero coefficients as identified by the single entity.

6. The method of claim **1**, wherein coding all non-zero coefficients as identified by the single entity is performed using an adaptive arithmetic coder.

7. The method of claim **1**, wherein coding all non-zero coefficients as identified by the single entity is performed using a semi-adaptive arithmetic coder.

8. The method of claim **1**, wherein coding all non-zero coefficients as identified by the single entity is performed using a non-adaptive arithmetic coder.

9. The method of claim **1**, wherein the single entity is a significance map.

10. A computer readable medium storing a computer program having instructions for controlling a computing device to identify non-zero coefficients in a block of image data having transformed coefficients the instructions comprising:

mapping a block of transform coefficients into a one-dimensioned list of transform coefficients in a fixed order:

generating a single entity; that identifies which transform coefficients in the one-dimensional list are non-zero;and

coding the single entity.

11. The computer readable medium of claim **10**, wherein the instructions further comprise coding the single entity based at least in part on a context of the single entity.

12. The computer readable medium of claim **10**, wherein the single entity is a bit vector.

13. The computer readable medium of claim **8**, wherein the single entity and the transform coefficients organized in the fixed order have a one-to-one correspondence between the coefficients and bits in the single entity.

14. The computer readable medium of claim **10**, further comprising coding all non-zero coefficients as identified by the single entity.

15. The computer readable medium of claim **14**, wherein coding all non-zero coefficients as identified by the single entity is performed using an adaptive arithmetic coder.

16. The computer readable medium of claim **14**, wherein coding all non-zero coefficients as identified by the single entity is performed using a semi-adaptive arithmetic coder.

17. The computer readable medium of claim **14**, wherein coding all non-zero coefficients as identified by the single entity is performed using a non-adaptive arithmetic coder.

18. The computer readable medium of claim **10**, wherein coding the single entity is accomplished using an adaptive arithmetic coder, a semi-adaptive arithmetic coder or a non-adaptive arithmetic coder.

19. The computer readable medium of claim **10**, wherein coding the single entity is accomplished using a semi-adaptive arithmetic coder.

20. The computer readable medium of claim **10**, wherein coding the single entity is accomplished using a non-adaptive arithmetic coder.

21. A method of decoding a bitstream, the method comprising: receiving a single entity that represents a mapping of a block of transform coefficients into a one-dimensional list of transform coefficients in a fixed order: decoding the single entity to identify which transform coefficients in the block are non-zero;and

converting the non-zero transform coefficients into block image data.

22. The method of claim **21**, wherein the single entity is a bit vector.

23. The method of claim **21**, wherein at least a portion of the bitstream is coded using a single entity that identifies which transform coefficients are non-zero and the non-zero transform coefficients are coded using an adaptive arithmetic coder.

24. The method of claim **21**, wherein at least a portion of the bitstream is coded using a single entity that identifies which transform coefficients are non-zero and the non-zero transform coefficients are coded using a semi-adaptive arithmetic coder.

25. The method of claim **21**, wherein at least a portion of the bitstream is coded using a single entity that identifies which transform coefficients are non-zero and the non-zero transform coefficients are coded using a non-adaptive arithmetic coder.

26. A computing device that decodes a bitstream, the computing device comprising:

a processor;

a module configured to control the processor to receive a single entity that represents a mapping of a block of transform coefficients into a one-dimensional list of transform coefficients in a fixed order;

a module configured to control the processor to decode the single entity to identify which transform coefficients in the block are non-zero;and

a module configured to control the processor to convert the non-zero transform coefficients into block image data.

27. The computing device of claim **26**, wherein the single entity is a bit vector.

28. The computing device of claim **26**, wherein non-zero transform coefficients were encoded using an adaptive arithmetic coder.

29. The computing device of claim **26**, wherein non-zero transform coefficients were encoded using a semi-adaptive arithmetic coder.

30. The computing device of claim **26**, wherein non-zero transform coefficients were encoded using a non-adaptive arithmetic coder.

31. A computer readable medium storing a computer program having instruction for controlling a computing device to decode a bitstream, the instructions comprising:

receiving a single entity that represents a mapping of a block of transform coefficients into a one-dimensional list of transform coefficients in a fixed order:

decoding a single entity to identify which transform coefficients in a block are non-zero; and

converting the non-zero transform coefficients into block image data.

32. The method of claim **31**, wherein the single entity is a bit vector.

33. The computer readable medium of claim **31**, wherein the single entity is coded to identify which transform coefficients are non-zero using an adaptive arithmetic coder.

34. The computer readable medium of claim **31**, wherein the single entity is coded to identify which transform coefficients are non-zero using a semi-adaptive arithmetic coder.

35. The computer readable medium of claim **31**, wherein the single entity is coded to identify which transform coefficients are non-zero using a non-adaptive arithmetic coder.

* * * * *

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United States Patent [19]

Krause et al.

[11] **Patent Number: 5,295,203**

[45] **Date of Patent: Mar. 15, 1994**

[54] **METHOD AND APPARATUS FOR VECTOR CODING OF VIDEO TRANSFORM COEFFICIENTS**

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[73] Assignee: **General Instrument Corporation**, Hatboro, Pa.

[21] Appl. No.: **858,102**

[22] Filed: **Mar. 26, 1992**

[51] **Int. Cl.**[5] **G06K 9/36**

[52] **U.S. Cl.** **382/56**; 358/433; 382/43

[58] **Field of Search** 382/56, 41, 27, 43, 382/21; 358/133, 433, 432; 364/826, 725; H04N 7/12

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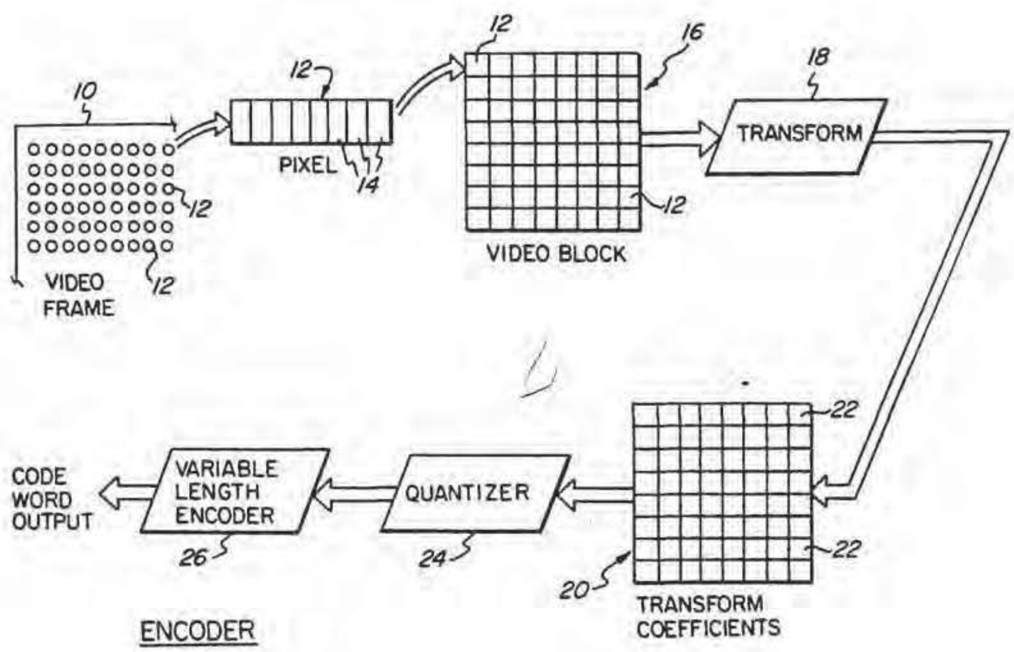
Primary Examiner—Joseph Mancuso
Attorney, Agent, or Firm—Barry R. Lipsitz

[57] **ABSTRACT**

A vector coding scheme for video transform coefficients is provided. A vector is generated to identify a group of coefficients from a block of transform coefficients that qualify for transmission according to predetermined criteria. In an illustrated embodiment, only coefficients having nonzero amplitudes are transmitted. The vector is encoded to provide a vector code word for transmission. The coefficients from the group qualifying for transmission are encoded to provide coefficient code words for transmission. The vector code word correlates the coefficient code words to coefficient locations in the block. In a preferred embodiment, the block is divided into a plurality of regions containing subsets of coefficients. A separate vector is transmitted for each region, correlating the coefficient code words to coefficient locations in the corresponding region of the block.

27 Claims, 6 Drawing Sheets



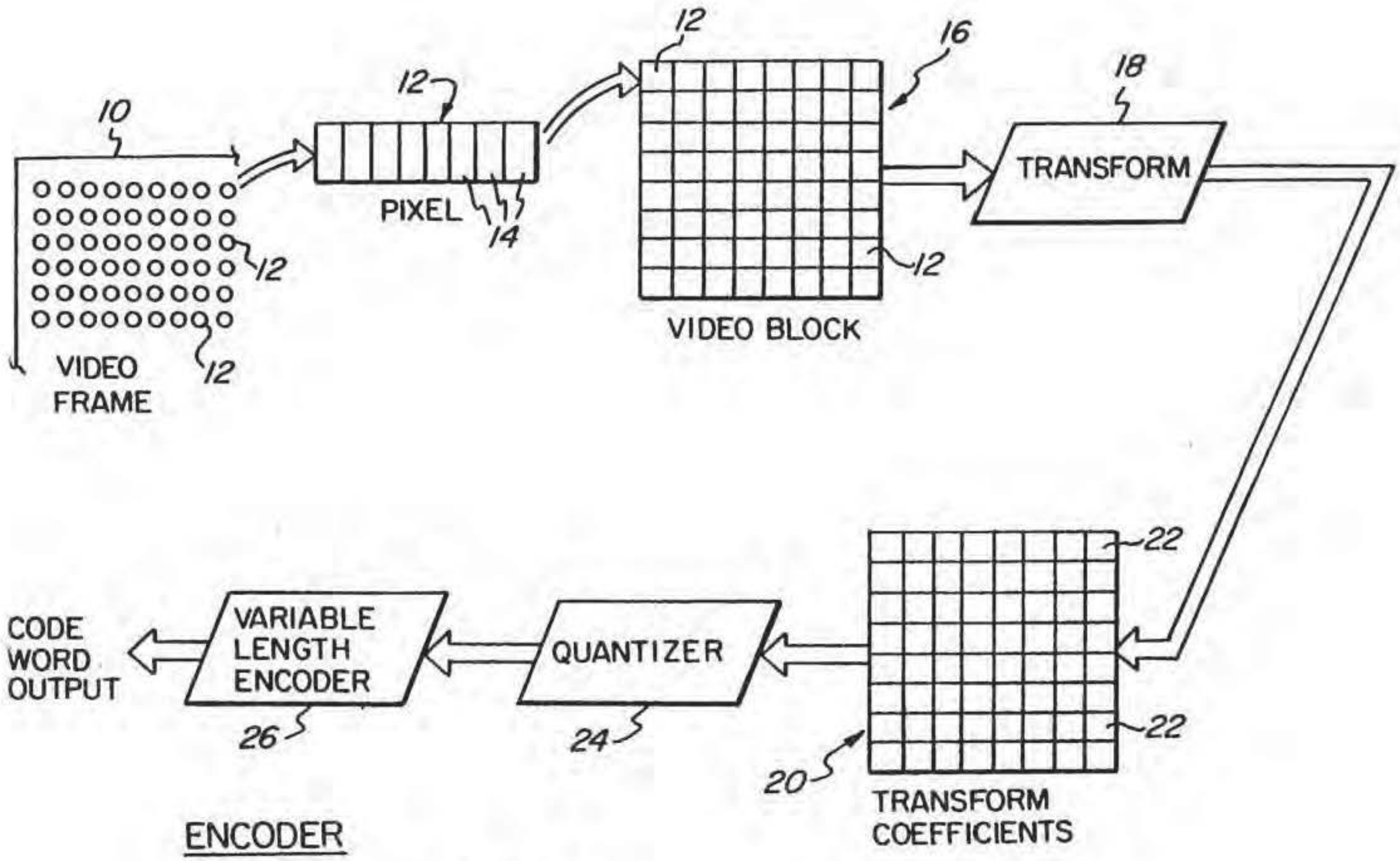
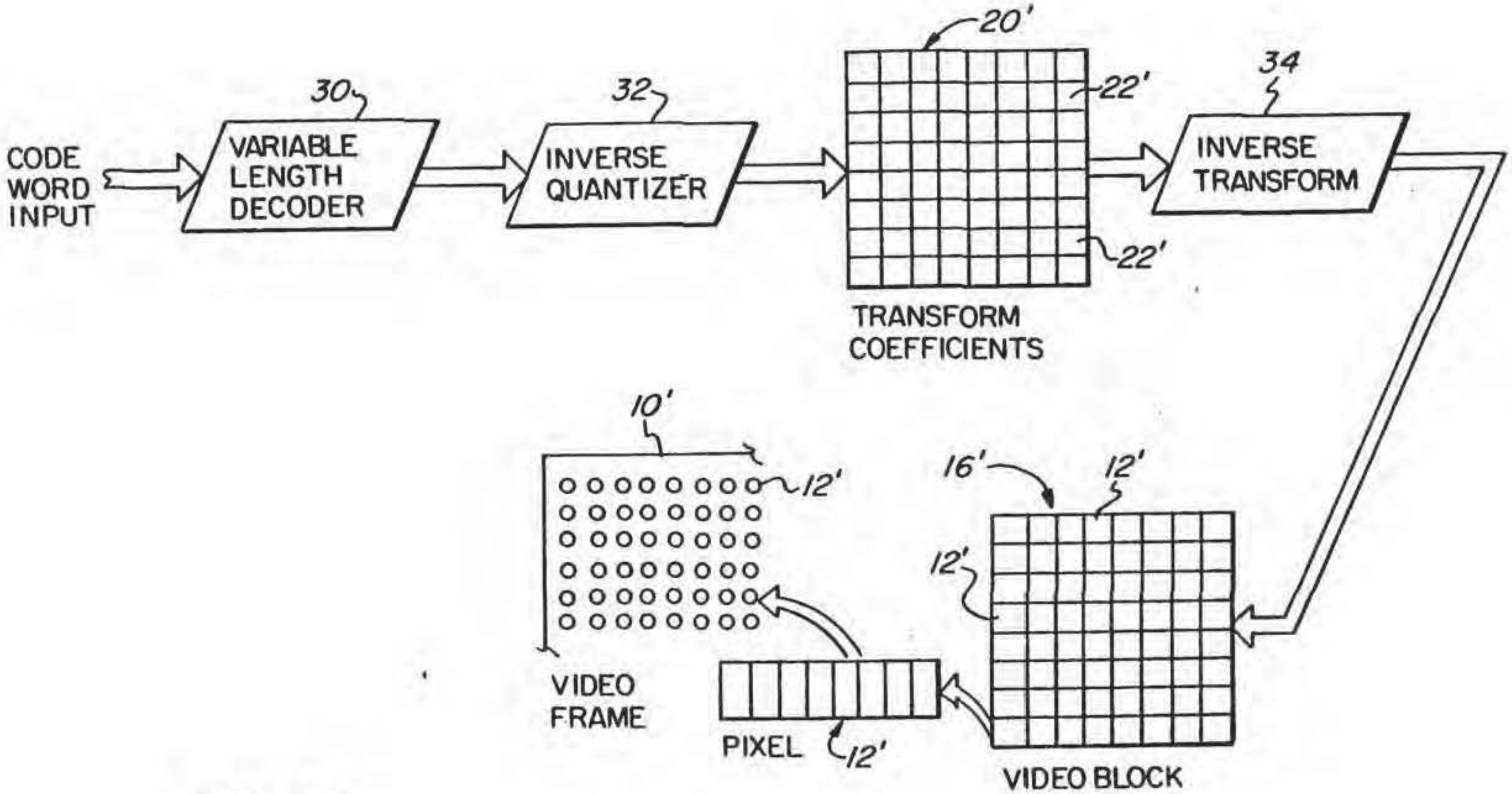

10
12
PIXEL
14
VIDEO FRAME
16
VIDEO BLOCK
18
TRANSFORM
22
20
TRANSFORM COEFFICIENTS
QUANTIZER
24
VARIABLE LENGTH ENCODER
26
CODE WORD OUTPUT
ENCODER

FIG. 1



DECODER

FIG. 2

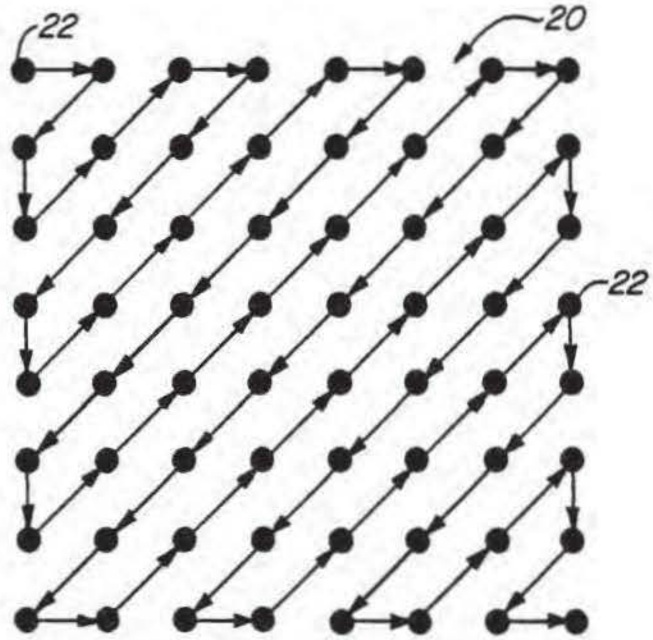


FIG. 3
(PRIOR ART)

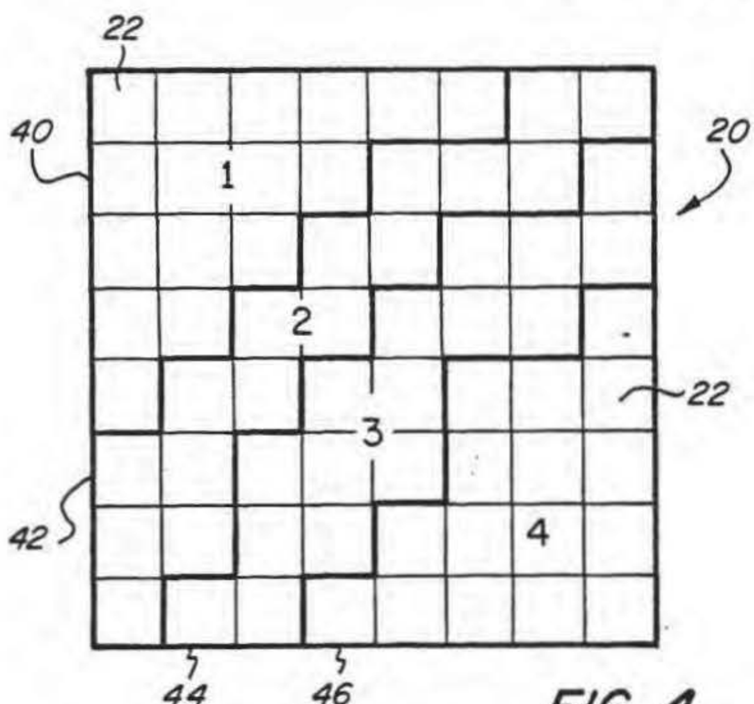


FIG. 4

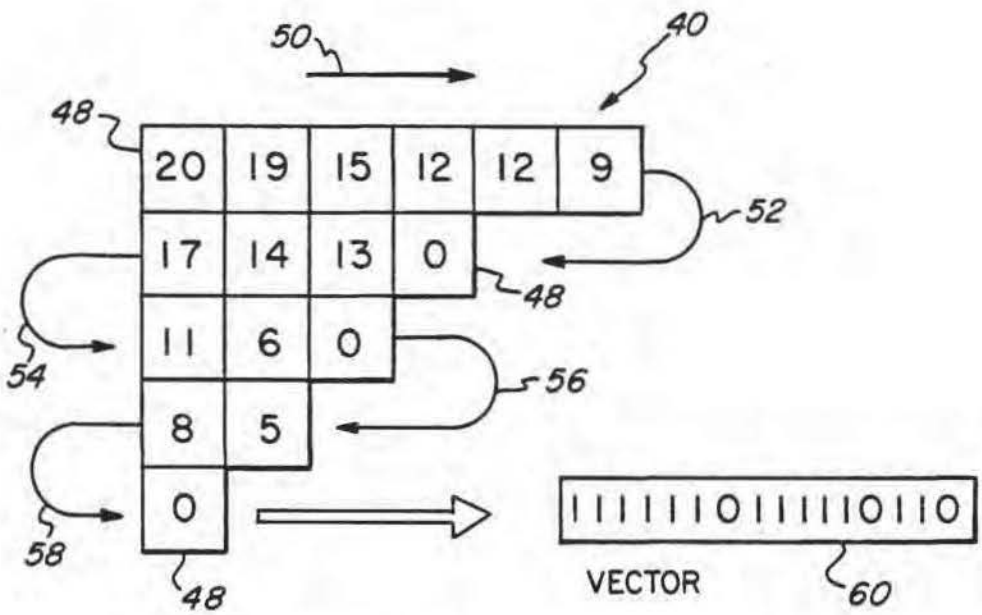

50
40
48
20
19
15
12
12
9
52
17
14
13
0
48
11
6
0
54
56
8
5
0
58
48
1111110111110110
VECTOR
60

FIG. 5

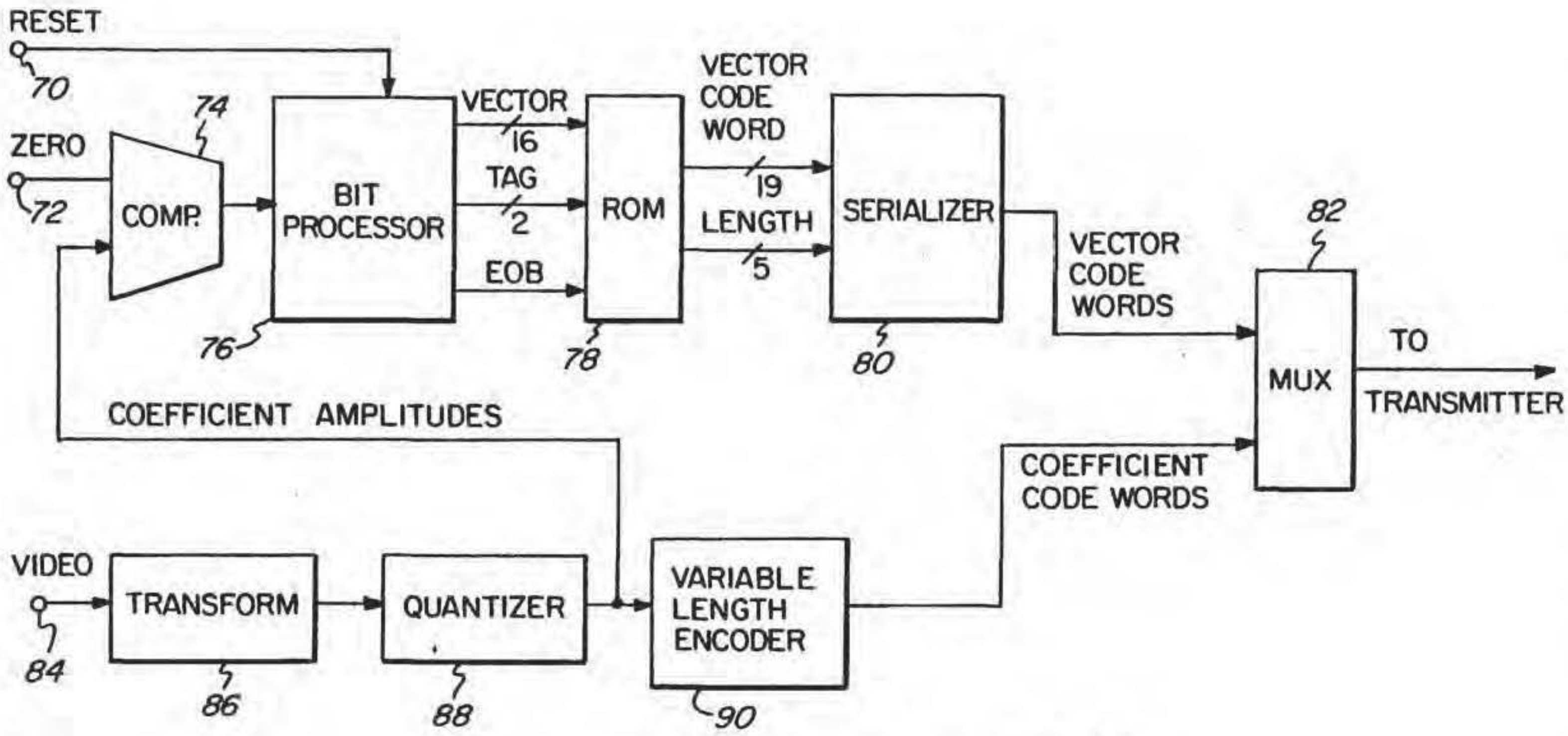

RESET
70
ZERO
72
74
COMP.
BIT PROCESSOR
76
VECTOR
16
TAG
2
EOB
ROM
78
VECTOR CODE WORD
19
LENGTH
5
SERIALIZER
80
VECTOR CODE WORDS
82
MUX
TO TRANSMITTER
COEFFICIENT AMPLITUDES
COEFFICIENT CODE WORDS
VIDEO
84
TRANSFORM
86
QUANTIZER
88
VARIABLE LENGTH ENCODER
90

FIG. 6

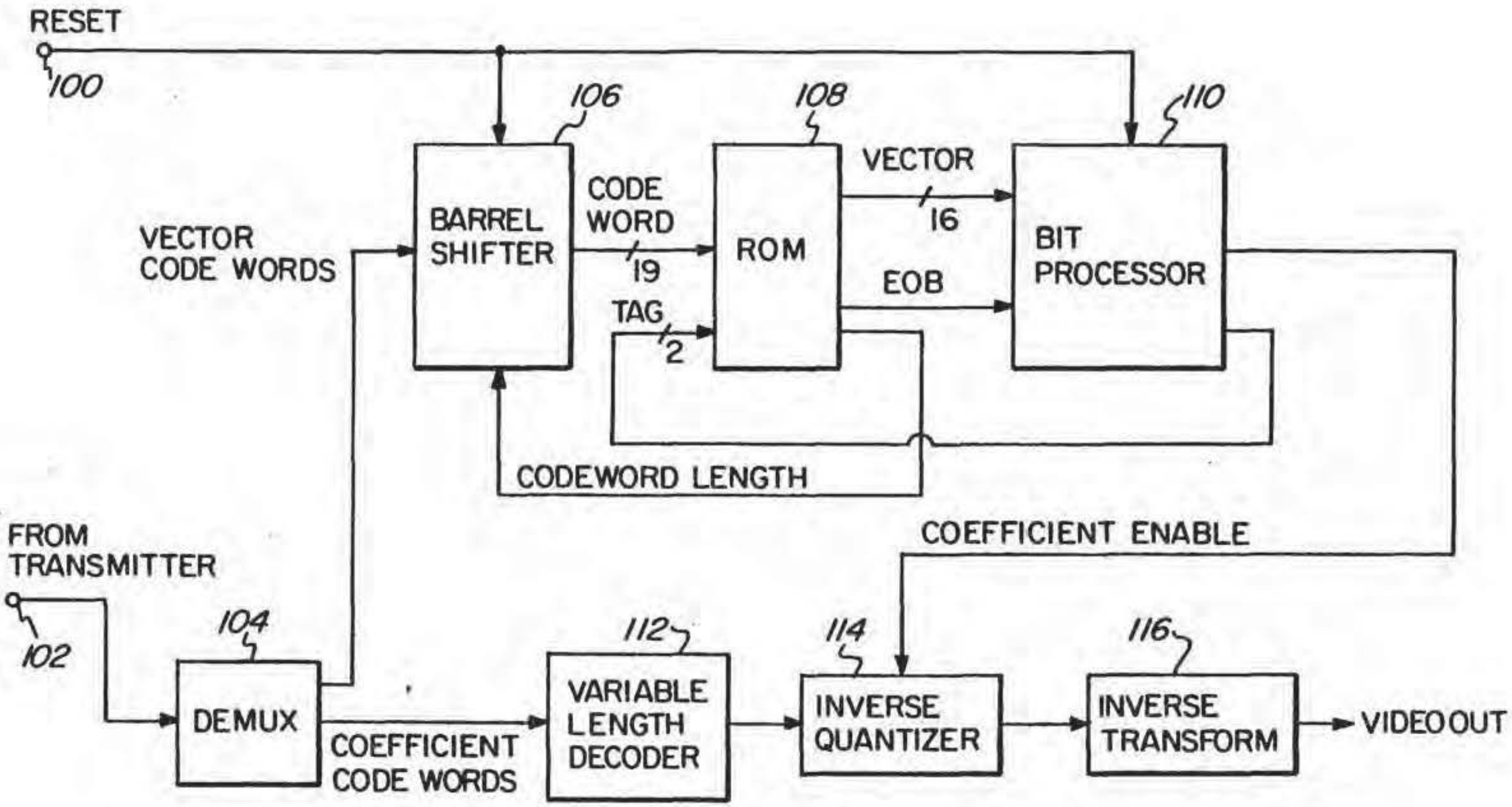

RESET
100
106
108
110
VECTOR CODE WORDS
BARREL SHIFTER
CODE WORD
19
ROM
VECTOR
16
EOB
BIT PROCESSOR
TAG
2
CODEWORD LENGTH
COEFFICIENT ENABLE
FROM TRANSMITTER
102
104
DEMUX
COEFFICIENT CODE WORDS
112
VARIABLE LENGTH DECODER
114
INVERSE QUANTIZER
116
INVERSE TRANSFORM
VIDEO OUT

FIG. 7

METHOD AND APPARATUS FOR VECTOR CODING OF VIDEO TRANSFORM COEFFICIENTS

BACKGROUND OF THE INVENTION

The present invention relates to the compression of digital video signals, and more particularly to a method and apparatus for processing digitized video signals for transmission in a compressed form.

Television signals are conventionally transmitted in analog form according to various standards adopted by particular countries. For example, the United States has adopted the standards of the National Television System Committee ("NTSC"). Most European countries have adopted either PAL (Phase Alternating Line) or SECAM (Sequential Color And Memory) standards.

Digital transmission of television signals can deliver video and audio services of much higher quality than analog techniques. Digital transmission schemes are particularly advantageous for signals that are broadcast by satellite to cable television affiliates and/or directly to home satellite television receivers. It is expected that digital television transmitter and receiver systems will replace existing analog systems just as digital compact discs have largely replaced analog phonograph records in the audio industry.

A substantial amount of digital data must be transmitted in any digital television system. This is particularly true where high definition television ("HDTV") is provided. In a digital television system, a subscriber receives the digital data stream via a receiver/descrambler that provides video, audio, and data to the subscriber. In order to most efficiently use the available radio frequency spectrum, it is advantageous to compress the digital television signals to minimize the amount of data that must be transmitted.

The video portion of a television signal comprises a sequence of video "frames" that together provide a moving picture. In digital television systems, each line of a video frame is defined by a sequence of digital data referred to as "pixels." A large amount of data is required to define each video frame of a television signal. For example, 7.4 megabits of data is required to provide one video frame at NTSC resolution. This assumes a 640 pixel by 480 line display is used with 8 bits of intensity value for each of the primary colors red, green and blue. High definition television requires substantially more data to provide each video frame. In order to manage this amount of data, particularly for HDTV applications, the data must be compressed.

Video compression techniques enable the efficient transmission of digital video signals over conventional communication channels. Such techniques use compression algorithms that take advantage of the correlation among adjacent pixels in order to derive a more efficient representation of the important information in a video signal.

One of the most effective and frequently used classes of algorithms for video compression is referred to as "transform coders." In such systems, blocks of video are linearly and successively transformed into a new domain with properties significantly different from the image intensity domain. The blocks may be nonoverlapping, as in the case of the discrete cosine transform (DCT), or overlapping as in the case of the lapped orthogonal transform (LOT). A system using the DCT is described in Chen and Pratt, "Scene Adaptive Coder," *IEEE Transactions on Communications*, Vol. COM-32, No. 3, March, 1984. A system using the LOT is described in Malvar and Staelin, "The LOT: Transform Coding Without Blocking Effects," *IEEE Transactions on Acoustics, Speech, and Signal Processing*, Vol. 37, No. 3, April, 1989.

Video transforms are used to reduce the correlation that exists among samples of image intensity (pixels). Thus, these transforms concentrate the energy into a relatively small number of transform coefficients. Most common transforms have properties that easily permit the quantization of coefficients based on a model of the human visual system. For example, the DCT produces coefficients with amplitudes that are representative of the energy in a particular band of the frequency spectrum. Therefore, it is possible to utilize the fact that the human viewer is more critical of errors in the low frequency regions of an image than in the high frequency or detailed areas. In general, the high frequency coefficients are always quantized more coarsely than the low frequencies.

The output of the DCT is a matrix of coefficients which represent energy in the two-dimensional frequency domain. Most of the energy is concentrated at the upper left corner of the matrix, which is the low frequency region. If the coefficients are scanned in a zigzag manner, starting in the upper left corner, the resultant sequence will contain long strings of zeros, especially toward the end of the sequence. One of the major objectives of the DCT compression algorithm is to create zeros and to bunch them together for efficient coding.

Coarse quantization of the low frequency coefficients and the reduced number of nonzero coefficients greatly improves the compressibility of an image. Simple statistical coding techniques can then be used to efficiently represent the remaining information. This usually involves the use of variable length code words to convey the amplitude of the coefficients that are retained. The smaller amplitudes which occur the most frequently are assigned short code words. The less probable large amplitudes are assigned long code words. Huffman coding and arithmetic coding are two frequently used methods of statistical coding. Huffman coding is used in the system of Chen and Pratt referred to above. Arithmetic coding is described in Langdon, "An Introduction to Arithmetic Coding," *IBM Journal for Research Development*, Vol. 28, No. 2, March, 1984.

In order to reconstruct a video signal from a stream of transmitted coefficients, it is necessary to know the location or address of each coefficient. Runlength coding is often used for this purpose. One form of runlength coding relies on a two-dimensional variable length coding scheme for sequences of quantized transform coefficients. In a given sequence, the value of a nonzero coefficient (amplitude) is defined as one dimension and the number of zeros preceding the nonzero coefficient (runlength) is defined as another dimension. The combination of amplitude and runlength is defined as an "event." In such a scheme, after a subset of an image frame has been transformed into a block of transform coefficients, only the nonzero coefficients are transmitted. Their addresses can be determined at the receiver by sending runlength codes. A single runlength code denotes the number of preceding zero amplitude coefficients since the last nonzero coefficient in the scan. As noted above, the coefficients within a block are usually

serialized using a zigzag scan order. Huffman or arithmetic coding can again be used to represent the runlength codes.

The runlength coding method suffers from various deficiencies. For example, the efficiency of the runlength coding method depends on the order in which the coefficients are scanned. In addition, the statistics of the runlength probability distribution vary depending on the location within the scan. This results in either additional complexity or reduced efficiency when assigning variable length code words to represent the runlength.

It would be advantageous to provide a method and apparatus for encoding video transform coefficient address information that overcomes the problems inherent in the runlength coding method. Such a method and apparatus should be straightforward to implement, and allow the mass production of reliable and cost efficient consumer decoders. The present invention provides a method and apparatus for identifying the locations of transmitted transform coefficients within a block, enjoying the aforementioned advantages.

SUMMARY OF THE INVENTION

In accordance with the present invention, a method is provided for coding video transform coefficients for communication. A block of transform coefficients is provided. A vector is generated to identify a group of coefficients from the block that qualify for transmission according to predetermined criteria. The vector is encoded to provide a vector code word for transmission. The coefficients from the group are encoded to provide coefficient code words for transmission. The vector code word correlates the coefficient code words to coefficient locations within said block.

In an illustrated embodiment, the block is divided into a plurality of regions containing subsets of coefficients. The vector identifies a group of coefficients that qualify for transmission in a first one of said regions. Additional vectors are generated to identify groups of coefficients that qualify for transmission in other regions of the block. The additional vectors are encoded as necessary for transmission.

The vectors produced for the various regions of the block can be analyzed in a predetermined order to determine if a set of one or more of the vectors meets an end-of-block criterion. For example, the end-of-block criterion can be met when there are no coefficients qualified for transmission in the set. In this instance, the vector from said block that immediately precedes said set is encoded as an end-of-block vector, and the vector encoding step is terminated without encoding the vectors contained in the set. Thus, once an end-of-block vector is received for a particular block, no further processing of that block is required. The remaining coefficients in the block (e.g., all zeros) are not transmitted.

In analyzing the vectors to determine if one or more meet the end-of-block criterion, the vectors can be tested in a predetermined order. This order progresses from vectors for regions that are least likely to contain coefficients qualified for transmission to vectors for regions that are successively more likely to contain coefficients qualified for transmission.

In the illustrated embodiment, the regions into which the blocks are divided each contain an equal number of coefficients. The first region comprises an area of the block that is likely to contain more coefficients qualified for transmission than any other region. The other regions of the block are successively less likely to contain coefficients qualified for transmission. For example, the coefficients qualified for transmission can be all of the nonzero coefficients in the block. The zero coefficients are not qualified for transmission.

The vectors representative of regions that contain coefficients qualified for transmission are transmitted with the coefficients for said region. The vectors representative of regions that have no coefficients qualified for transmission are not transmitted unless followed by a vector for another region in the block that does contain coefficients qualified for transmission.

In an alternate vector quantizer embodiment, the locations of the coefficients qualifying for transmission are compared to a limited number of vectors contained in a vector library. A vector is chosen from the library to identify the group based on a predetermined matching criteria. The matching criteria can comprise, for example, the match between an actual vector and a vector in the library that produces the lowest error when one is subtracted from the other.

Encoder apparatus is provided for coding video transform coefficients for communication. The encoder apparatus includes means for converting a portion of video data to a block of transform coefficients. Means are also provided for generating a vector to identify a group of coefficients from the block that qualify for transmission according to predetermined criteria. The vector is encoded to provide a vector code word for transmission. The coefficients that qualify for transmission are also encoded to provide coefficient code words for transmission. The vector code word correlates the coefficient code words to coefficient locations in the block.

The encoder apparatus can further comprise memory means for storing a plurality of code words that identify all of the different possible combinations of coefficients qualified for transmission in the block. In such an embodiment, there will be a separate code word for each of the different possible vectors. The vector encoding means select the code word from the memory that identifies the combination of coefficient locations which matches the locations of the group of coefficients identified by the vector.

In another embodiment, the memory means store a plurality of code words that identify a limited number of the different possible combinations of coefficients qualified for transmission in the block. The vector encoding means select the code word that identifies the combination of coefficient locations represented in the memory which best matches the locations of the group of coefficients identified by the vector, in accordance with a best match criterion.

In the illustrated embodiment, the encoder apparatus includes means for dividing the block into a plurality of regions containing subsets of the coefficients. The vector identifies a group of coefficients that qualify for transmission in a first one of the regions. Additional vectors are generated to identify groups of coefficients that qualify for transmission in other regions of the block. The additional vectors are encoded as necessary.

The encoder apparatus can further comprise means for analyzing the vectors produced for the regions to determine if at least one of the vectors meets an end-of-block criterion. If so, an end-of-block signal is generated. The end-of-block criterion can be met, for example, when at least one vector indicates that there are no

further coefficients qualified for transmission in the block. In this manner, the transmission of unnecessary (e.g., zero) coefficients can be avoided. In the illustrated embodiment, the analyzing means search for vectors that meet the end-of-block criterion by testing the vectors in a predetermined order progressing from vectors for regions that are least likely to contain coefficients qualified for transmission to vectors for regions that are successively more likely to contain coefficients qualified for transmission.

The regions into which the block is divided can each contain an equal or substantially equal number of coefficients. The first region can comprise an area of the block that is likely to contain more coefficients qualified for transmission than any other region. The other regions of the block are successively less likely to contain coefficients qualified for transmission.

Decoder apparatus in accordance with the present invention comprises means for receiving encoded coefficients representing video data from a block of a video image area. Means are also provided for receiving an encoded vector corresponding to a group of the encoded coefficients. Means are provided for decoding the encoded vector to recover a vector that identifies locations for the coefficients in the block. Means responsive to the vector decode the encoded coefficients from the group to recover the block with the coefficients in substantially proper locations thereof.

The encoded vector can be received by the decoder apparatus in the form of a variable length code word. Memory means provided in the decoder apparatus store a plurality of vectors that identify different possible combinations of coefficient locations in the block. The received vector code word is used to address the memory means to output a vector that best identifies the actual locations of the coefficients in the block. In an alternate embodiment, a state machine is provided instead of the memory means for decoding the encoded vector in response to the received vector code word.

The block of video image area that the received encoded coefficients corresponds to can comprise a plurality of regions containing different groups of the coefficients. In such an embodiment, the decoder apparatus receives and decodes separate encoded vectors for the different groups of coefficients. The coefficient decoding means are responsive to the separate vectors for assembling the different groups of coefficients into substantially proper locations in the block.

The encoded vectors can include overhead data that is detected and processed by the decoder apparatus. For example, means can be provided for detecting a region tag from the overhead data, said tag identifying the region of the block to which a current vector corresponds. The vector decoding means are responsive to the tag for decoding the current vector.

An end-of-block signal can also be detected from the overhead data. Means, operatively associated with the coefficient decoding means and responsive to the end-of-block signal, fill regions of the block that follow the detection of the end-of-block signal with predetermined filler coefficients. Such coefficients can comprise, for example, zeros.

In another embodiment, a received vector can be encoded as an end-of-block vector. Means, operatively associated with the coefficient decoding means and responsive to the detection of an end-of-block vector, fill regions of the block following the region defined by the end-of-block vector with predetermined filler coefficients.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic illustration showing the operation of an encoder for transforming video data into variable length code words for transmission;

FIG. 2 is a diagrammatic illustration of a decoder for converting the variable length code words output from the encoder of FIG. 1 back to video data for display on a television set or the like;

FIG. 3 is a diagram illustrating a zigzag scanning order used in prior art encoders to serialize a block of transform coefficients;

FIG. 4 is a diagram illustrating the division of a block of transform coefficients into regions in accordance with the present invention;

FIG. 5 is an illustration showing how a first region of FIG. 4 might be scanned in order to provide a vector in accordance with the present invention;

FIG. 6 is a block diagram illustrating encoder apparatus in accordance with the present invention; and

FIG. 7 is a block diagram illustrating decoder apparatus in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a new technique designated "vector coding," for use in communicating data via a variable length encoder and variable length decoder. The vector coding technique disclosed herein relates to the addressing of transform coefficients that are selected for transmission. Unlike the prior art run-length coding technique, the vector coding process of the present invention does not depend on the order in which the coefficients are scanned Other advantages of the vector coding technique over prior art techniques will be apparent from the discussion which follows.

FIG. 1 illustrates, in diagrammatic form, the operation of an encoder for converting video data into variable length code words for transmission. A video frame 10 comprises a plurality of lines of pixel data. Each pixel 12 is represented by a digital word comprising eight bits 14 that define video luminance or chrominance information. A conventional digital television image will comprise on the order of 640 pixels across the frame for each of 480 horizontal lines that extend from the top of the frame to the bottom of the frame. High definition television provides substantially more pixels per line and lines per frame.

As illustrated in FIG. 1, an encoder for encoding the video information will typically arrange a plurality of pixels into a video block 16. In the illustrated embodiment, the pixels from each video frame are grouped into 8×8 blocks, for a total of 64 pixels per video block. The video blocks that contain the pixel data are each transformed by a conventional transform coder 18 to provide corresponding blocks 20 of transform coefficients 22. Transform coder 18 can implement, for example, either of the well known discrete cosine or lapped orthogonal transforms.

Block 20 of transform coefficients 22 is quantized using known techniques by a quantizer 24, which outputs the quantized coefficients to a variable length encoder 26 that outputs code words representative of the individual transform coefficients. The code words are transmitted to one or more receivers via a communication channel in a conventional manner.

At a receiver, the code words are decoded to recover the original video data, using a decoder as illustrated in FIG. 2. The received code words are input to a variable length decoder 30 to recover quantized transform coefficients. The recovered quantized coefficients are inverse quantized in an inverse quantizer 32. The resultant transform coefficients are reassembled into a block 20', containing individual recovered transform coefficients 22'. The recovered block of transform coefficients is inverse transformed as indicated at 34, to recover a block of video data 16' containing pixels 12'. The pixels are then output to a television receiver or the like, to recreate a video frame 10'.

In the prior art, it has been conventional to scan the transform coefficients 22 of block 20 in a zigzag fashion, as shown in FIG. 3, to serialize the coefficient data for transmission. Since there is a high likelihood that the upper left-hand corner of the block will contain nonzero coefficients, and that any zero coefficients will be found toward the lower right corner of the block, such a zigzag scanning arrangement results in a higher probability that long runlengths of zero will be obtained. With runlength coding, this result generally enables a higher compression to be achieved.

In the vector coding scheme of the present invention, no particular scanning pattern is required to maintain a high compression efficiency. In accordance with the present invention, a unique code word is used to specify a subset of coefficients that is selected for transmission within a block of transform coefficients, or within portions of the block referred to as "regions." In a preferred embodiment, all possible combinations of coefficients that could be selected for transmission from a block or region are accounted for and a unique code word is provided to describe each combination. Efficiency is achieved by assigning variable length codes, such as Huffman or arithmetic codes, to each different group of coefficients that could be selected in a block or region. The most probable coefficient selections are assigned the shortest code words. Conversely, the combinations of coefficients that are least likely to be selected are assigned the longest code words. These code words completely specify the group of coefficients selected for transmission from each block or region, and are transmitted to a receiver to enable received coefficients to be properly located in successive blocks of transform coefficients. When the properly located transform coefficients are inverse transformed, the pixel data within the resultant video blocks will be arranged in the right order for reproduction on a video display.

In the embodiment illustrated herein, only coefficients with amplitudes greater than zero after quantization are transmitted. The amplitude codes for these coefficients are transmitted in any predetermined scan order. Unlike runlength coding, the scan order in which the amplitude codes are transmitted does not effect the compression efficiency.

The number of possible coefficient combinations (i.e., locations in a block of transform coefficients having zero and nonzero entries) increases very rapidly as a function of the number of coefficients in the block or region. For example, the most popular transforms produce blocks of 8×8 coefficients. In this case, there are 2^{64} possible combinations of coefficients which are nonzero. Since it is not easy to implement a system capable of encoding or decoding this many code words, it is desirable to reduce the size of the region that is vector coded. For example, a block of 8×8 DCT or LOT coefficients can be subdivided into four regions as shown in FIG. 4. Each region 40, 42, 44, 46 contains 16 transform coefficients 22. The DCT and the LOT both have the characteristic of producing coefficients representative of the amount of energy in different frequency bands. In FIG. 4, the horizontal frequency increases from left to right. Vertical frequency increases from top to bottom. The top left coefficient represents the DC or average energy in the entire block. The bottom right coefficient corresponds to the energy that is visible in the form of diagonal lines having the maximum frequency possible given the horizontal and vertical pixel sampling rate.

For most imagery, the energy is concentrated into the low frequency coefficients. These are the coefficients closest to the top left corner of the block illustrated in FIG. 4. The first region 40, which will be represented by a first vector, was chosen in order to maximize the number of coefficients that are likely to be greater than zero. The second region 42, third region 44, and fourth regions 46 will be represented by separate vectors. These regions were chosen using the same selection criterion (i.e., maximizing the number of nonzero coefficients) but applied to the remaining coefficients only. It should be appreciated that the region boundaries illustrated in FIG. 4 are exemplary only, and that different areas can be chosen for the regions. Also, there may be more or fewer than the four regions illustrated.

FIG. 5 illustrates an example of how a vector can be formed by scanning the coefficients included in first region 40 of the block of transform coefficients. The numbers within the boxes 48 represent the actual amplitudes of the sixteen coefficients residing in the region. In the example illustrated, the top row of the coefficients is scanned from left to right as indicated by arrow 50. The second row is scanned from right to left as indicated by arrow 52. The third row is scanned from left to right as indicated by arrow 54, and the fourth row is scanned from right to left as indicated by arrow 56. Finally, the bottom coefficient in the region is scanned as illustrated by arrow 58. A vector is formed on the basis of the scanning to indicate whether each of the sixteen coefficients has an amplitude of zero or greater than zero. If the amplitude is greater than zero, the coefficient will be transmitted, and a logic one will be entered into the vector for that coefficient. If a coefficient has an amplitude of zero, it will not be transmitted and the vector will include a logic zero representative of the coefficient. Thus, vector 60 contains a sixteen bit word "1111110111110110" that designates which of the coefficients from the region are qualified for transmission, according to the order in which the coefficients of the region have been scanned. A receiver that receives vector 60 will know that there is no new coefficient in a received data stream for any of the "zero" entries in the vector. Instead of decoding a received code word for each of the "zero" entries, the receiver will merely insert a zero into the appropriate coefficient location within the region currently being received. It should be appreciated that any other scanning order can be used to form the vectors, as the efficiency of the vector coding method does not depend on any particular scanning order.

FIG. 6 illustrates, in block diagram form, an encoder that can be used to implement the vector coding scheme of the present invention. Blocks of video pixel data are input via terminal 84 to a transform coder 86 that can implement, for example, the DCT. The resultant coeffi-

cient amplitudes are input to a quantizer **88** and variable length encoder **90** in a conventional manner to provide coefficient code words for transmission. The quantized coefficient amplitudes are also input, in accordance with the present invention, to a comparator **74** that compares each of the coefficient amplitudes to a zero amplitude input at terminal **72**. The comparator outputs a logic one if the coefficient is not equal to zero and a logic zero otherwise. A bit processor **76** receives the decision bits from the comparator and produces three outputs. The first output is the vector obtained by repackaging the decision bits into sixteen bit words, such as vector **60** illustrated in FIG. **5**. Each bit of this word corresponds to one of the sixteen coefficients in one of the four vector partitions **40, 42, 44, 46** illustrated in FIG. **4**. Two "tag" bits are provided to indicate which of the four vector partitions ("regions") is currently being encoded.

An additional end-of-block (EOB) bit is output by bit processor **76** in order to further improve coding efficiency. The EOB bit indicates whether there are any remaining nonzero coefficients in the vectors which follow. For example, if the first vector (the vector from region **40**) is being encoded, then the EOB bit will be set high if there are no remaining nonzero coefficients in the second, third or fourth vectors from regions **42, 44, 46**, respectively. If the second vector is being encoded, then the EOB bit will be set high if there are no remaining nonzero coefficients in the third or fourth vectors. In the case of the third vector, the EOB bit indicates whether there are additional nonzero coefficients in the fourth vector. The EOB bit serves no purpose when encoding the last of the four vectors. The significance of applying the EOB bit as an input to the ROM is that it allows the assignment of one of two different code words to represent the same vectors. The first code word is selected if the EOB bit is a logic zero, and indicates not only addressing information for the current region but also that there are additional nonzero coefficients to follow. The second code word is used if the EOB bit is a logic one and indicates that all remaining coefficients in the block are zero, and therefore the encoding process can be terminated early.

Bit processor **76** is reset at the beginning of each block. A reset signal for this purpose is input to the bit processor via terminal **70**. All of the functions of the bit processor can be easily implemented in a single programmable logic device.

A read-only memory (ROM) **78** is used to map the sixteen bit coefficient word, the two bit region tag, and the EOB bit from bit processor **76** into a unique variable length code word. The length of the code word is also output by the ROM in order to concatenate the code words into a serial stream for transmission. The maximum code word length in the implementation illustrated in FIG. **6** is nineteen bits. The vector code word and length from ROM **78** are serialized in a conventional serializer circuit **80** for output to a multiplexer **82**. At this point, the vector code words are multiplexed with the coefficient code words from variable length encoder **90**, to provide a digital data stream for transmission.

An implementation of a vector decoder in accordance with the present invention is illustrated in FIG. **7**. The digital data stream received from the encoder is input to a demultiplexer **104** via terminal **102**. The demultiplexer separates the vector code words from the coefficient code words. The coefficient code words are input to a variable length decoder **112**, that can comprise a ROM which outputs the quantized coefficients represented by the code words. These code words are inverse quantized in section **114**, which assembles the transform coefficients back into their block form. The inverse quantizer is responsive to a coefficient enable signal derived from the vector, which indicates the positions of all zero amplitude coefficients in the original block of transform coefficients. The recovered block of transform coefficients is inverse transformed in section **116**, for output of the recovered blocks of video pixel data.

The vector code words output from the demultiplexer **104** are input to barrel shifter **106**, either in a serial or parallel format. The barrel shifter outputs nineteen bits, corresponding to the maximum code word length, which are then used to address a ROM **108**. The ROM is addressed by two additional region tag bits output from a bit processor **110**. These bits indicate which region of a block of transform coefficients is currently being processed (i.e., which of the four vectors is being decoded). Those skilled in the art will appreciate that the maximum code word length can be limited to less than nineteen bits, if necessary to accommodate a ROM with an address size of fewer than twenty-one total bits, with little effect on compression efficiency. Alternatively, a plurality of ROMs can be combined or higher density static or dynamic RAM could be used to provide a larger memory capacity. In an alternate embodiment, a state machine can be substituted for ROM **108** to generate the vector, EOB and code word length data from the received code words. The use of a state machine is advantageous because it can be implemented at a relatively low cost, which is desirable for consumer decoders.

ROM **108** has three outputs. The first is the decoded vector indicating which of the sixteen coefficients have been transmitted for the region currently being decoded. The second is the EOB bit telling the bit processor **110** to either continue or discontinue receiving the remaining vectors of the block. The third ROM output is the actual length of the decoded code word. This is used by the barrel shifter to synchronize with the beginning of the next code word. The bit processor converts the parallel input ROM data to a serial stream of sixty-four bits which are output in the desired block scan order. These "coefficient enable" bits are input to inverse quantizer **114** to identify the coefficients that were selected at the encoder for transmission. The bit processor also identifies the vector that is currently being decoded via the two bit region tag. Both the bit processor and the barrel shifter are reset at the beginning of each block, via a reset signal input to terminal **100**. As with the encoder, the decoder bit processor can be easily implemented in a single programmable logic device.

In an alternate embodiment, the vector coder of the present invention can be implemented as a vector quantizer. The difference is that the vector quantizer can only transmit a limited number of vector selection patterns. Each time a new vector is observed, it is compared to a list of allowed vectors stored in a vector library, to determine which is the best match. The code word corresponding to the best matching vector is then transmitted to the decoder even if it requires that the amplitude of some coefficients be forced to zero, or if it requires some coefficients with a zero amplitude to be transmitted. The latter case requires that a special zero

amplitude code word be reserved when transmitting the coefficient values.

A disadvantage of the vector quantization scheme is that the encoder will require additional complexity to determine the best match between the actual vector for a region, and a vector contained in the vector library. However, the vector quantization scheme has the advantage that the memory requirements are reduced and a slight improvement can be achieved in the efficiency of the vector code words due to the reduced number of possible vectors.

It should now be appreciated that the present invention provides a new and improved technique for coding video transform coefficients. Coefficient code words representative of coefficients qualified for transmission (e.g., nonzero coefficients) are transmitted together with vector code words. The vector code words correlate the coefficient code words to coefficient locations in a block of transform coefficients. In a preferred embodiment, the blocks of transform coefficients are divided into a plurality of regions, that are chosen to maximize the number of coefficients that are likely to be greater than zero for a first vector, with subsequent regions producing vectors that are successively less likely to contain nonzero coefficients. The invention can be implemented as either a vector coder or a vector quantizer.

Although the invention has been described in connection with a specific embodiment thereof, those skilled in the art will appreciate that numerous adaptations and modifications may be made thereto, without departing from the spirit and scope of the invention as set forth in the claims.

What is claimed is:

1. A method for coding video transform coefficients for communication comprising the steps of:

providing a block of transform coefficients;

generating a vector to identify locations of a group of coefficients from said block that qualify for transmission according to predetermined criteria;

encoding said vector to provide a vector code word for transmission; and

encoding the coefficients from said group to provide coefficient code words for transmission;

wherein said vector code word correlates the coefficient code words to coefficient locations in said block.

2. A coding method in accordance with claim 1 comprising the further step of:

dividing said block into a plurality of regions containing subsets of coefficients, said vector identifying a group of coefficients that qualify for transmission in a first one of said regions; and

generating additional vectors for encoding to identify locations of groups of coefficients that qualify for transmission in other regions of said block.

3. A coding method in accordance with claim 2 comprising the further steps of:

analyzing the vectors produced for said regions in a predetermined order to determine if a set of said vectors meets an end of block criterion;

encoding the vector from said block that immediately precedes said set as an end of block vector if said criterion is met for said set; and

terminating said vector encoding step without encoding the vectors in said set.

4. A coding method in accordance with claim 3 wherein said end of block criterion is met when there are no coefficients qualified for transmission in said set.

5. A coding method in accordance with claim 4 wherein:

said predetermined order progresses from vectors for regions that are least likely to contain coefficients qualified for transmission to vectors for regions that are successively more likely to contain coefficients qualified for transmission.

6. A coding method in accordance with claim 2 wherein:

said regions each contain a substantially equal number of coefficients;

said first region comprises an area of said block that is likely to contain more coefficients qualified for transmission than any other region; and

the other regions of said block are successively less likely to contain coefficients qualified for transmission.

7. A coding method in accordance with claim 6 wherein:

the vectors representative of regions that contain coefficients qualified for transmission are transmitted with the coefficients for said region; and

no vectors are transmitted for regions that have no coefficients qualified for transmission unless followed by a vector for a region that does contain coefficients qualified for transmission.

8. A coding method in accordance with claim 1 wherein said vector generating step comprises the steps of:

comparing the locations of said group of coefficients qualifying for transmission to locations designated by a limited number of vectors contained in a vector library; and

choosing a vector from said library to identify said group based on predetermined matching criteria.

9. A coding method in accordance with claim 8 comprising the further step of dividing said block into a plurality of regions containing different subsets of the coefficients contained in the block; wherein:

said regions each contain a substantially equal number of coefficients;

a first region comprises an area of said block that is likely to contain more coefficients qualified for transmission than any other region; and

the other regions of said block are successively less likely to contain coefficients qualified for transmission.

10. A coding method in accordance with claim 9 wherein:

said vector identifies the locations of a group of coefficients that qualify for transmission in said first region;

additional vectors are generated to identify the locations of groups of coefficients that qualify for transmission in the other regions of said block;

vectors representative of regions that contain coefficients qualified for transmission are transmitted with the coefficients for said region; and

no vectors are transmitted for regions that have no coefficients qualified for transmission unless followed by a vector for a region that does contain coefficients qualified for transmission.

11. Encoder apparatus for coding video transform coefficients for communication comprising:

means for converting a portion of video data to a block of transform coefficients;

means for generating a vector to identify locations of a group of coefficients from said block that qualify for transmission according to predetermined criteria;

means for encoding said vector to provide a vector code word for transmission; and

means for encoding the coefficients from said group to provide coefficient code words for transmission;

wherein said vector code word correlates the coefficient code words to coefficient locations in said block.

12. Encoder apparatus in accordance with claim 11 further comprising:

memory means for storing a plurality of code words that identify all of the different possible combinations of coefficients qualified for transmission in said block;

wherein said vector encoding means select the code word from said memory that identifies the combination of coefficients qualified for transmission which matches the locations of the group of coefficients identified by said vector.

13. Encoder apparatus in accordance with claim 11 further comprising:

memory means for storing a plurality of code words that identify a limited number of the different possible combinations of coefficients qualified for transmission in said block;

wherein said vector encoding means select the code word that identifies the combination of coefficients qualified for transmission represented in said memory which best matches the locations of the group of coefficients identified by said vector, in accordance with a best match criterion.

14. Encoder apparatus in accordance with claim 11 further comprising:

means for dividing said block into a plurality of regions containing subsets of said coefficients, said vector identifying locations of a group of coefficients that qualify for transmission in a first one of said regions; and

means for generating additional vectors for encoding to identify the locations of groups of coefficients that qualify for transmission in other regions of said block.

15. Encoder apparatus in accordance with claim 14 further comprising:

means for analyzing the vectors produced for said regions to determine if one of said vectors meets an end of block criterion; and

means for encoding a vector meeting said end of block criterion to identify it as an end of block vector.

16. Encoder apparatus in accordance with claim 15 wherein said end of block criterion is met when there are no subsequent vectors in said block that identify locations for coefficients which are qualified for transmission.

17. Encoder apparatus in accordance with claim 16 wherein said analyzing means search for vectors that meet the end of block criterion by testing said vectors in a predetermined order that progresses from vectors for regions that are least likely to contain coefficients qualified for transmission to vectors for regions that are successively more likely to contain coefficients qualified for transmission.

18. Encoder apparatus in accordance with claim 14 wherein:

said regions each contain a substantially equal number of coefficients;

said first region comprises an area of said block that is likely to contain more coefficients qualified for transmission than any other region; and

the other regions of said block are successively less likely to contain coefficients qualified for transmission.

19. Encoder apparatus in accordance with claim 14 further comprising:

memory means for storing a plurality of code words that identify all of the different possible combinations of coefficients qualified for transmission in said block;

wherein said vector encoding means select the code word from said memory that identifies the combination of coefficients qualified for transmission which matches the locations of the group of coefficients identified by a vector to be encoded.

20. Encoder apparatus in accordance with claim 14 further comprising:

memory means for storing a plurality of code words that identify a limited number of the different possible combinations of coefficients qualified for transmission in said block;

wherein said vector encoding means select the code word that identifies the combination of coefficients qualified for transmission represented in said memory which best matches the locations of the group of coefficients identified by a vector to be encoded, in accordance with a best match criterion.

21. Decoder apparatus for decoding video transform coefficients comprising:

means for receiving encoded coefficients representing video data from a block of a video image area;

means for receiving an encoded vector corresponding to a group of said encoded coefficients;

means for decoding said encoded vector to recover a vector that identifies locations for said coefficients in said block; and

means responsive to said vector for decoding the encoded coefficients from said group to recover said block with said coefficients in substantially proper locations thereof.

22. Decoder apparatus in accordance with claim 21 wherein said encoded vector is received as a code word, said apparatus further comprising:

memory means for storing a plurality of vectors that identify different possible combinations of transmitted coefficient locations in said block;

wherein said code word is used to address the memory means to output a vector that best identifies the actual locations of the transmitted coefficients in said block.

23. Decoder apparatus in accordance with claim 21 wherein:

said encoded vector is received as a code word; and

said means for decoding said encoded vector comprise a state machine responsive to said code word.

24. Decoder apparatus in accordance with claim 21 wherein:

said block comprises a plurality of regions containing different groups of said coefficients;

separate encoded vectors are received and decoded for the different regions; and

said coefficient decoding means are responsive to the separate vectors for assembling the different groups of coefficients into substantially proper locations in said block.

25. Decoder apparatus in accordance with claim 24 wherein said encoded vectors include overhead data, said apparatus further comprising:

means for detecting a region tag from said overhead data, said tag identifying the region of said block to which a current vector corresponds;

wherein said vector decoding means are responsive to said tag for decoding the current vector.

26. Decoder apparatus in accordance with claim 25 further comprising:

means for detecting an end of block signal from said overhead data; and

means, operatively associated with said coefficient decoding means and responsive to said end of block signal, for filling subsequent regions of said block with predetermined filler coefficients.

27. Decoder apparatus in accordance with claim 24 further comprising:

means for detecting if one of said received vectors is encoded as an end of block vector; and

means, operatively associated with said coefficient decoding means and responsive to said detecting means, for filling regions of said block following the region defined by said end of block vector with predetermined filler coefficients.

* * * * *

CERTIFICATE OF SERVICE

I hereby certify that on this 13th day of July, 2016, I caused the foregoing Brief For Appellant to be electronically filed with the Clerk of the Court for the United States Court of Appeals for the Federal Circuit through the Court's CM/ECF system.

/s/ Constantine L. Trela, Jr.
CONSTANTINE L. TRELA, JR.

CERTIFICATE OF COMPLIANCE

This brief complies with the type-volume limitations of Federal Rule of Appellate Procedure 32(a)(7)(B) and the Rules of this Court, because it contains 13,525 words as determined by the Microsoft 2007 word-processing system used to prepare the brief, excluding the parties of the brief exempted by Federal Rule of Appellate Procedure 32(a)(7)(B)(iii).

This brief complies with the typeface requirements of Federal Rule of Appellate Procedure 32(a)(5) and the type-style requirements of Federal Rule of Appellate Procedure 32(a)(6) because it has been prepared in a proportionally spaced typeface using the Microsoft Word 2007 word-processing system in 14-point Times New Roman font.

/s/ Constantine L. Trela, Jr.
CONSTANTINE L. TRELA, JR.